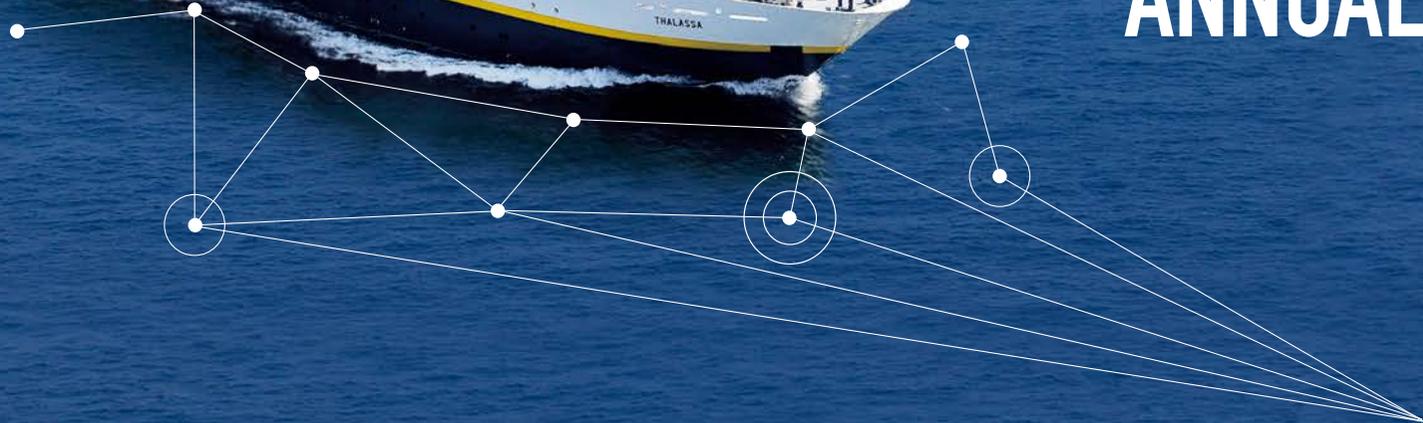




2016 ANNUAL REPORT



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IFREMER IN BRIEF

Created on 5 June 1984, Ifremer, as the national institute for integrated research in marine sciences, relies on its observational and monitoring capacities to produce scientific knowledge and know-how with economic value in response to societal issues.

Ifremer is a public institute of industrial and commercial nature (EPIC status), placed under the joint supervision of the Ministry of education, higher education and research and the Ministry of the environment, energy and the sea.

Through a systemic approach, Ifremer plays a part in marine environmental observation on all scales and in understanding ecosystems, the processes governing them and the services they help provide, in a context of global change.

To these ends, it designs and deploys infrastructures for marine environmental research and monitoring and tools for observation and experimentation, and manages databases.

It operates a significant part of the French oceanographic fleet on behalf of the entire scientific community.

Missions

Ifremer contributes to national and European strategies for research and innovation, by producing:

- fundamental knowledge;
- more finalised results to respond to questions raised by society;
- results and technologies contributing to the socio-economic development of the maritime world.

Organisation

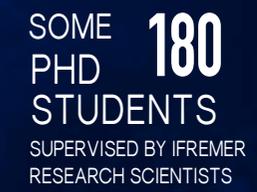
Ifremer has a three-stranded organisation:

- the scientific and technological strand which includes the scientific management, the Fleet resources and operations division and four departments: Biological resources and environment (RBE), Physical resources and deep-sea ecosystems (REM), Oceanography and ecosystems dynamics (ODE) and marine and digital infrastructures (IMN);
- the support for research strand is delivered by five functional divisions (administration, finances and legal affairs; human resources; business development; communications; international and European affairs) and the accounts department;
- the territorial strand comprises five centres managing a network of locations, including those in overseas France.



KEY FIGURES

EXPERTS REPORTS AND ADVICES **238**



SINCE 2014, IFREMER HAS BEEN INVOLVED IN **31 H2020 PROJECTS**, IN COORDINATING 3 OF THEM



© Ifremer/S.Vandoolaeghe

INTERVIEW WITH FRANÇOIS JACQ

Chairman and Chief
Executive Officer

“ Ifremer, serving marine sciences and technologies ”

What were the milestones for 2016?

The collective work carried out in the framework of assessments by the High council for the evaluation of research and higher education (HCERES) was obviously of prime importance in 2016. It enabled us to think about our practices, and our strengths and limitations alike, and identify the stakes for the future.

The joint research units (UMR) from the second wave B (EIO in Tahiti; LOPS, Amure, LM2E and Lemar in Brest) were evaluated and their scientific projects validated. These projects were described as excellent. The success of this wave illustrates the relevance of our Institute’s policy of openness, which enables us to both ensure specific missions and establish fruitful collaboration.

The Merlin (acronym for MER: *Lancement d’initiatives nouvelles*) projects launched in 2016 are designed to encourage consensus-generating new initiatives that will enhance the Institute’s potential for scientific discovery. They have already made it possible to begin new cooperation and raised the interest of our partners on themes with linkages between fundamental knowledge and social expectations.

The past year was also important in the field of infrastructures: more than ever, the designing and managing of facilities and infrastructures is at the core of our Institute’s activity. Specific examples are the launching of the European ERIC EMSO (European Multidisciplinary Seafloor and water-column Observatory) plan, where Ifremer is leading the French contribution in close partnership with CNRS, and the operational phase for HROV *Ariane* which supplements the range of underwater vehicles with a new, more flexible, tool.

In the realm of support for public policies (APP), another essential component of the Institute's activity, special focus was concentrated on drawing up the programme to collect and analyse fisheries data in the framework of the EU Common Fisheries Policy (CFP), by formalising the 2017-2019 work plan, where Ifremer is a major contributor, notably through two hundred cruise days at sea.

About the projects submitted by Ifremer in the first calls for proposals in the frame of the European H2020 framework programme, the initial indicators are positive...

The European Commission presented a progress report for its 2014/2015 work plan, and this measures our drive in proposing projects.

Ifremer has made clear progress in this field. Our Institute's success rate for H2020 calls is 28%, higher than the national success rate and the European average. Therefore, this is a highly satisfactory initial result which should prompt us to pursue our efforts in developing European networks.

You submitted a proposal for the unification of the French oceanographic fleet to Thierry MANDON, Secretary of State in charge of Higher Education and Research, who validated it. How long will it take to effect this transformation?

I was given this remit personally and not as a representative of Ifremer, but obviously, it could have significant consequences for the Institute.

The general idea developed in the report is that the current situation where the fleet's management is split up between four institutes probably does not allow full benefit to be drawn from French strengths and skills, including to establish international alliances.

Thus, the proposal is to create unified management of the fleet, backed up by Ifremer. The Ministry in charge of research validated this orientation and asked that it be implemented by early 2018. This will require working with current stakeholders daily, to ensure that the transition takes place under the best possible conditions.

The aim is to best meet the needs of the scientific community by implementing a high-quality scientific programme with flexible positioning of vessels and optimised use of resources. In this framework, Ifremer will become an operational service provider to the benefit of one and all.

What other challenges must Ifremer rise to in 2017?

Ifremer is currently in a special situation, owing to the transfer of our headquarters to the Plouzané campus, slated for 2019. The year 2016 was marked by the staff mobility management agreement finalised with the unions. It should enable the operation to be carried out within an exemplary social context, aiming to limit the loss of skill sets and ensure efficient hand-over of dossiers within the teams. This will most certainly be a crucial point in the next two years.

Another important example of work related to in-house operations concerns the upgrading of our budget and accountancy management and information system. Putting the new management software suite into operation in 2017 is a major step. We must now ensure that it is efficiently deployed and reap the benefits for improved management of the Institute.

You have also launched an approach concerning ethics. What is your objective?

Ifremer deals with often sensitive issues, at the intersection of knowledge, technology, public policy and societal expectations. This requires exceptionally high and strict standards on everyone's part.

To help us in our process of reflection, we have joined the ethics committee set up by Cirad and INRA, which seems to be a highly productive way to share thoughts about often similar challenges and stakes, especially in the field of living resources.

Furthermore, concerns related to professional ethics and scientific integrity are increasingly pressing. In the wake of approaches launched nationwide, Ifremer has drawn up its professional ethics charter and set up an in-house approach to raise awareness and provide support. It should enable us to even better fulfil our missions, in compliance with the core values of scientific practice.

How do you see the Institute's future?

Ifremer must assert itself as a reference institution for marine sciences and technologies, capable of unifying the efforts conducted in this field.

Ifremer is developing an integrated approach to better understand the oceans and their resources. Its originality lies in the conjunction of great diversity in missions and expertise. This is a French specificity. It makes directing the Institute a demanding task, to ensure that various balances are respected, but is also the basis of what makes our model rich and comprehensive.

2016: THE YEAR IN PICTURES

MARCH

Thierry MANDON, Secretary of State in charge of higher education and research visiting Ifremer's Brittany centre

Thierry MANDON took advantage of this visit to present François Jacq with the official remit to prepare, then implement, closer integration of the French research fleet's various components.



© Ifremer/O. Dugornay



© Ifremer/S. Lesbats

APRIL

Barbara POMPILI, Secretary of State in charge of biodiversity visiting Ifremer's Brittany centre

The studies Ifremer is conducting on marine diversity were presented to her on this occasion.



© Society of Environmental Toxicology and Chemistry

MAY

Organisation of the 26th annual meeting of the Society of environmental toxicology and chemistry (Setac Europe) at the *Cité des Congrès* conference centre in Nantes.

Ifremer was the local organiser for this international conference attracting over 2,000 scientists from more than sixty countries working in environmental sciences. With an impressive programme of 1,800 papers presented in seventy-seven sessions, this was the largest international meeting of its kind held in Europe in 2016.

MAY

Ifremer delegation in South Korea in the framework of the France-Korea Year

This trip provided the opportunity for a working group meeting on subsea technologies between the Korea Institute of Ocean Science and Technology (Kioist) and Ifremer.



© Kioist-2016

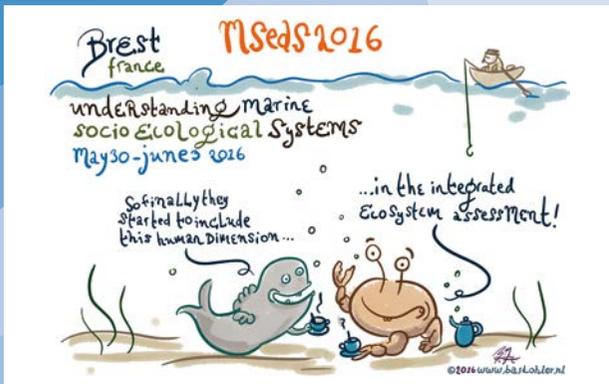
JUNE

Polymetallic nodule exploration licence granted by ISA

The request for extension of the exploration contract for polymetallic nodules signed between the International Seabed Authority (ISA) and Ifremer, submitted in December 2015, was accepted on 20 June 2016 for a five-year period.



© Ifremer/Nautilie /Nodinaut/2014



JUNE

SUCCESS OF THE FIRST INTERNATIONAL SYMPOSIUM ON "UNDERSTANDING MARINE SOCIO-ECOLOGICAL SYSTEMS" (MSEs) IN BREST.

This event was organised by the marine economics and law research centre UMR Amure (Ifremer-UBO-CNRS) and supported by the International Council for Exploration of the Sea (ICES) and the North Pacific Marine Science Organization (PICES). It brought together 240 participants from nearly one hundred research bodies and universities.



7th MARITIME FESTIVAL EVENT IN BREST

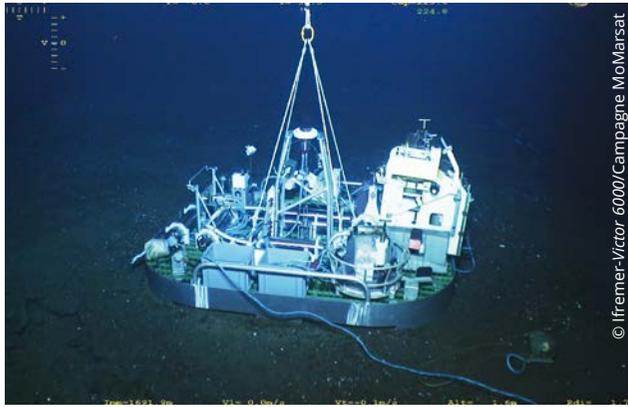
JULY

This event was an occasion to raise the general public's awareness about maritime innovation in the region of Brittany in the field of marine sciences and technologies. Visitors could come aboard Ifremer's ocean research vessel *Thalassa*, whilst the *Quai des sciences* venue provided outreach activities on the Ocean and climate theme, involving numerous Ifremer staff members.

AUGUST

Renewal of the framework agreement between French Polynesia and Ifremer for a five-year period

Ifremer's Pacific centre, located at Vairao on the peninsula of Tahiti, will thus pursue its work to support the development of local marine value chains there.



SEPTEMBER

With EMSO, Europe kicks off a new system to coordinate multidisciplinary underwater observatories

The first meeting of EMSO (European Multidisciplinary Seafloor and water column Observatory) members was held on 28-29 September in Rome, Italy being the facility's host country; Ifremer and CNRS ensure the French contribution and governance within EMSO-France.



© Ifremer/J. Bourjea

SCIENTIFIC POLICY

Ifremer is a research body with relatively small staffing, whose mobilising remit covers a large range of activities (research, environmental monitoring, maintaining sophisticated infrastructures, providing expertise, supporting public policy making, developing economic value, etc.), within highly diverse themes. In this context, Ifremer's scientific policy aims to ensure that the research conducted achieves both excellence and relevance while meeting the expectations expressed by stakeholders in the framework of the Institute's missions and priorities. Its scientific policy is broken down into various actions which go from the scientific management's facilitation and incentive-building to various forms of national and international partnerships.



21 POST-DOC
FELLOWS

84 SALARIED PHD STUDENTS

IN 2016 30 PHD STUDENTS RECEIVED A HALF-STIPEND PAID BY IFREMER

IFREMER IS A PARTNER IN **9** JOINT
RESEARCH UNITS (UMR)
AND IS THE SUPERVISORY
AUTHORITY FOR EIGHT OF THEM

SOME **180**
PHD STUDENTS
SUPERVISED BY IFREMER
RESEARCH SCIENTISTS



Merlin projects

The Merlin projects were launched in 2016, the outcome of in-depth reflection within Ifremer to devise and encourage new unifying and iconic initiatives for our institute. They will receive in-house and financial support for at least three years, aiming to engage a few projects which could open new research fronts for the Institute complementing its current work and studies underway.

With the Merlin projects, Ifremer has chosen to mobilise its multidisciplinary talents and give itself the means for new ocean exploration at the boundaries of existing technologies and concepts.



© Drone studio

Bluefin tuna tagging programme

Popstar

This project aims to develop innovative beacons to monitor the movement of fish in their natural environment using miniaturized sensors. The new sensors will make it possible to investigate fish's behaviour and movements and monitor both their physiological state (heartbeat, lipid levels) and environmental parameters (temperature, depth, irradiance). Miniaturizing the sensors will also open new pathways for exploring the behaviour and movements of a greater number of species. Other innovations are foreseen to improve the accuracy of data acquired and optimise energy management.

Popstar is conducted by Ifremer in close collaboration with the joint research units UMR LIRMM (Montpellier Laboratory of informatics, robotics and microelectronics, University of Montpellier - CNRS) and UMR Marbec (Marine Biodiversity, Exploitation and Conservation, CNRS, IRD, University of Montpellier and Ifremer).

Microplastics

The massive production of plastic has led to the accumulation of plastic waste in the world ocean. Plastic waste is omnipresent in the environment and in the marine realm, being photo-degraded by UV and weakened and eroded under the effect of multiple pressures (mechanical, biological, and so on). This leads to its fragmentation into increasingly smaller bits of debris (called microplastics between 1 and 5 mm and nanoplastics between 500 nm and 1 µm) which are found in the water column, in sediments and in marine organisms.

However, a significant difference can be seen between the quantities measured on land and those observed in the surface layer of the ocean. Therefore, their fate remains largely unknown. These particles are furthermore suspected of being hazardous for health. Through the Merlin Microplastics project, Ifremer proposes to support vital action to help overcome the obstacle of sampling and identifying microplastics in the marine environment.

This Merlin project will cooperate, for some major methodological developments such as collecting and characterising the smallest plastic particles, with the ANR-Nanoplastics project (Institute of molecules and materials, University of Maine, France) which began 2016, for a four-year period. The Microplastics project is conducted by Ifremer, along with the UMR Lemar (Marine environmental science laboratory, CNRS-UBO-IRD-Ifremer) joint research unit, Cedre (Centre of documentation, research and experimentation on accidental water pollution), the Laboceia laboratory, the private-sector firm Horiba (manufacturing measurement instruments and optical equipment) and IPCF (Italian institute for physical and chemical processes).



© Ifremer/E. Malmeca

Plastic debris washed up on a beach

The Abyss

Inventorying and characterising biodiversity, at sea and on land, has gained momentum in the past few years thanks to new molecular screening techniques (DNA metabarcoding to quickly identify species), which supplement conventional studies by combining genetic barcode identification and taxonomics. Molecular studies and investiga-

tions have shown that the deep sea is full of species which possess an exceptional physiology. However, knowledge about the biodiversity in this realm remains quite limited.

The objective of this Merlin project is to explore these ecosystems (i.e. this biome) using molecular tools to improve knowledge about deep-sea biodiversity and study the large-scale distribution.

Labelling strategy for Ifremer networks in the shore and coastal infrastructure (I-LICO)

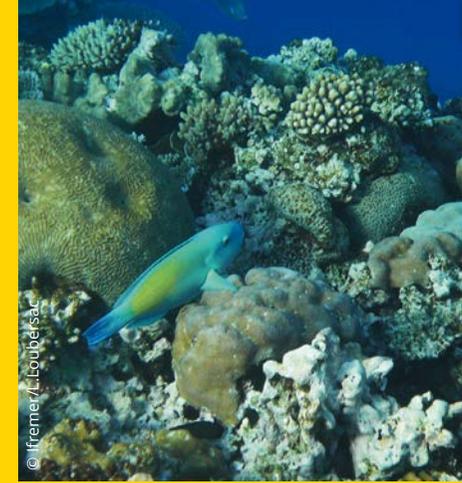
To enhance the value and development of the observation work done by its networks, since 2015, Ifremer has invested in an approach to qualify for the quality label for two of them: the network for phytoplankton monitoring (Réphy, total flora) and that for high-frequency monitoring (HF, physical-chemical and biogeochemical measurements). The Coast-HF (Coastal Ocean observing System – High Frequency) and the micro-phytoplankton observatory on the French coast dossiers were set up jointly with CNRS and the Somlit (coastal environment observation

service) national observation service (SNO), thus extending the scope of its application for quality label approval to cover phytoplankton and high-frequency measurements.

These networks are an integral part of the I-LICO research infrastructure (RI) which brings together eight monitoring networks or services for the coastal environment (either labelled or planning to be) operated by CNRS INSU, IRD, SHOM, IGN and Ifremer. They are: Moose (Mediterranean Ocean Observing System on Environ-

ment), Dynalit (coastal and shoreline dynamics), Réphy-Somlit, Coast-HF, Corail (observatory of coral reefs in Polynesia and the Pacific), Reef-temps (coastal water temperature sensor array in the South and South-west Pacific region) and Sonel (coastal water level monitoring system).

The RI, initially coordinated by Ifremer and CNRS, will finalise the structuring and the labelling of its networks in 2017, relying if necessary on CNRS INSU special committees.



Corals in New Caledonia



La Pérouse library in Brest

Scientific and technical information service (IST) - La Pérouse library

Ifremer's IST services is hosted by the La Pérouse library (BLP), the marine documentation centre which has been common to IRD, UBO and Ifremer since 2003.

Its prime purpose is to serve Ifremer's scientific community by meeting its requests for documentation. The services provided take the forms of:

- input, administration and accessibility to the Archimer institutional archives;
- bibliometric studies (based on Archimer and databases such as *Web of Science*)

which can valorise scientific production and research infrastructures;

- scientific intelligence, proposing to draw up a state of the art prior to research projects and/or by constantly accompanying projects, thus taking part in foresight studies;
- access to scientific literature through journals, by subscription or through Open Access and to bibliographic reference databases;
- training in documentary research;
- advice and expertise in terms of intellectual property, including copyrights.

As of recently, the service now reports to scientific management guiding the Institute's research policy, making it more reactive and relevant.

AllEnvi foresight study on environmental scenarios (ScenEnvi)

The Alliance for environmental sciences (AllEnvi) tasked its transversal group to make a general study of the scenarios proposed by international foresight studies, including environmental scenarios. The foresight project team selected ninety-nine recent studies whose horizons were 2030, 2050 and 2100, with global or continental spatial scopes. Analysis of three hundred seven scenarios described in these studies highlighted three major driving factors, i.e. governance, economics and societies. On the other hand, the environmental dimension, like those of science and technology and even demographics, only seems to be a secondary factor in the scenarios. The systematic review analysis of the scenarios identified eleven families, all telling contrasting "stories of the future". These eleven families can be grouped into three types of trajectory: that of decline (made up of the families of "fragmentation", "retreat" and "chaos"); trajectories not assigning priority to the environment ("inertia", "growth at any

price", "social priorities") and proactive trajectories giving priority to the environment ("local", "reaction", green growth", "proactive" and "positive synergy"). The first two trajectories include a marked deterioration of the environment (climate, air, soil, water, sea). Although the pathways with environmental priority often lead to partial or total improvement of the environment, this is not always assured and degradations which may be reversible in part or not at all, are envisaged in half of the scenarios in these families. The fields of the ocean, coast and forest are rarely mentioned as specific subjects for research. Confronted with rather pessimistic scenarios in terms of the environment (57% of the three-hundred seven scenarios), governance remains the major form of leverage for action, in both the short and the long term. Despite the growing number of different types of networks, in this governance, the state or supranational approach remains predominant, without any explicit subsidiarity relay to the civil society. This analysis sheds light on the main challenges for research in coming years and should help define future scientific orientations.

INTERVIEW



Maxime LAFONT
PHD STUDENT

The subject of your PhD thesis highlights the fact that molluscs, and particularly oysters, have a kind of immune memory.

Could you tell us more about the subject of your thesis?

For a decade, Pacific oyster farms have been affected by episodes of massive mortality, notably involving the OsHV-1 virus. Like all invertebrates, oysters have no lymphocytes and do not produce antibodies. That means that they do not possess the elements involved in the specific immune response and the immune memory phenomenon which exists in all vertebrates. However, studies have recently raised the question as to whether an immune memory and adaptive immune priming mechanisms exist in different species of invertebrates, without relying on lymphocytes and antibodies.

I have an Ifremer-University of Perpignan Via Domitia (UPVD) grant for my thesis, being done in the framework of the Provi-gas project (antiviral protection in the *Crassostrea gigas* oyster-financed by the Occitanie region and conducted by Caroline MONTAGNANI) within the UMR Interactions hosts - pathogens - environments (IHPE) joint research unit. My work is focusing on studying the antiviral immune priming which has been shown in laboratory studies of the oyster. Immune priming defines the fact that an initial contact with a pathogenic agent leads to better immune defence the second time an organism is in contact with the same pathogen.

What are the concrete objectives?

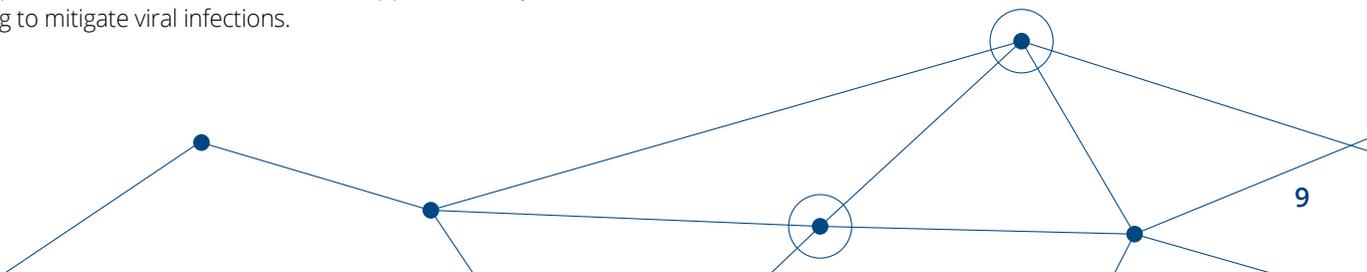
I'm looking for the potentialities of immune priming to protect oyster spat (oysters less than a year old) in case of massive mortality episodes. The following questions have been raised: can oysters be specifically protected from viral or bacterial infections? How long would this protection last? What molecular mechanisms are involving in immune priming and immune memory? In a word, opening the possibilities to stimulate immunity to help determine solutions against infectious diseases affecting shellfish.

What was your aim in spending time studying in an Australian university?

I responded to the 2016 call for international mobility for PhD students proposed by Ifremer's scientific management and received a three-month study grant. Thanks to the collaborative work established between my laboratory and Macquarie University in Sydney, I was able to work on a project focusing on the transmission of antiviral protection to the next generation (transgenerational priming): can spat be protected using immunity thus developed in broodstock? These studies aim to develop new tools which are secure and applicable to oyster farming to mitigate viral infections.

What are the strong points of this international cooperation?

This collaborative work gave me training in numerous techniques enabling the study of immune priming, from rearing broodstock, to their breeding, to molecular and protein analyses. My stay also enabled me to discuss and create scientific ties with Australian researchers, especially with Dr Timothy GREEN and Prof. David RAFTOS, whose innovative work in this field is widely acknowledged, to formulate research issues and in the long term, publish scientific articles. This experience is a true career opportunity for a young research scientist.





Integrated research on the ocean and global change

Against the backdrop of global change related to the climate, increasing pressure on the oceans by human activities and growing demand for marine resources, scientists have noted many modifications in the ocean: higher temperatures, rising sea level, acidification of sea water, altered biological communities, etc. This manifests the fact that the ocean is a regulator of the “climate machine”.

In coming years, Ifremer’s main ambitions are to better diagnose both past and present global change, better understand the processes governing the ocean and thus help predict the future state of the oceans.

Research is also focusing on how the wealth of resources in the ocean are formed. It holds potential reserves of food, raw materials and energy, which can contribute to the sustainable development of our planet and the well-being of its inhabitants, providing they are used in an enlightened way.

Observing the oceans over the long term

Space-borne observation of the oceans has really taken off over the past few years. Satellites can now appraise elements like surface temperature and salinity, the principal currents, the extent and the movements of sea ice, concentrations of phytoplankton and wave height. However, *in situ* observation remains essential for integrated knowledge of the oceans (in terms

of physics, chemistry, biology) and validation of data.

The international Argo programme is a global array for ocean monitoring which complements satellite observations. The programme deploys and maintains over 3,800 autonomous drifting floats, which can supply temperature and salinity profiles (and biogeochemical parameters in some cases) for every sea on earth, and at depths reaching 2,000 metres.

This vital observation network pursues two aims: to detect climate variability from one year to another and thus supply data to build analytical models for long-term climate change in oceans and to supply the information needed to calibrate and validate satellite data or ocean models.

Ifremer plays an essential role in this programme, in the fields of profiling float science and technology and as the operator of one of Argo’s two world data centres.

The Equipex NAOS project in the investments for the future programme (PIA), coordinated by Ifremer and led along with Pierre & Marie Curie University, is preparing the developments for Argo in the next decade (measuring biogeochemical and deep-sea parameters).

Understanding how the ocean helps regulate the climate

By absorbing and heat and atmospheric carbon dioxide (CO₂), oceans contribute to regulating the climate on the global scale. Effectively, one fourth of the carbonic gas emitted from the combustion of fossil fuels and 90% of the heat produced by the growing greenhouse effect are absorbed by surface sea waters before being carried into the deep sea by ocean currents.

The objective of the Ovide programme is to help understand and quantify this process and its variability, by analysing the properties and circulation of water masses in the northern part of the North Atlantic. This programme observing the North Atlantic subpolar gyre has taken measurements at a hundred points along a leg going from Portugal to the south of Greenland every two years since 2002. Indeed, most of the deep water of the world ocean is formed to the north-east of this line, driving the “meridional overturning circulation” which conditions how the ocean will influence the climate. In 2016, a new Ovide programme cruise (Bocats cruise) was performed, led by the Spanish partners from the University of Vigo and with Ifremer’s active participation. It complements this time series which is essential for our understanding of these phenomena.

Understanding the effects of climate change

We are beginning to quantify the consequences of climate warming on the oceans. Several phenomena related to the rise in temperature are being observed: the melting of glaciers and the sea-ice extent, rising sea levels, and so on.

Using geological records especially helps us understand how landscapes change in response to modifications in the way the climate machine functions.

Studying land-sea transfers of sediment (from source to sink) is one of Ifremer’s lines of research in marine geosciences. It makes it possible to understand the mechanisms of sediment formation and the path they take to ocean basins (continental erosion, transport, marine deposits) by identifying and quantifying the forcings involved. What makes Ifremer’s approach so singular is that it links complex marine environments (pro-delta, ocean slopes, turbidity systems, etc.) and past climate fluctuations which have left traces of their impact on continental erosion and sedimentary fluxes.

This research gives the keys to decipher the true “climate records” that the architecture of ancient deposits provides. Thus, past, unknown or poorly documented climate events have been reconstructed. So, all these studies contribute to the overall understanding of paleoclimates which is indispensable for future climate projections. In coming years, Ifremer’s objective is to extend these studies to new realms, working on quantifying the impact of past sea-level fluctuations on paleo-environments in reefs.

In another context, Ifremer is also studying how living organisms respond to changes in their environment (higher temperature, deoxygenation, acidification and eutrophication). For instance, for the past decade, both in France and in Europe, shellfish farming has been confronted with a series of massive mortality episodes affecting different species of shellfish. These episodes can be partly explained by the presence of various pathogenic agents. Seeing the context, Ifremer is working to better characterise the complex interactions which can exist between shellfish, the pathogenic organisms involved and the environment, where modifications linked to global change may promote the emergence of infectious diseases. The Institute has brought together twenty-one partners from the public and private sectors in the European Vivaldi consortium, which won a call for Horizon 2020 projects in 2016. The project led by this consortium aims to improve the European shellfish farming sector’s sustainability and competitiveness by developing tools and approaches to better prevent and mitigate diseases in marine bivalves.

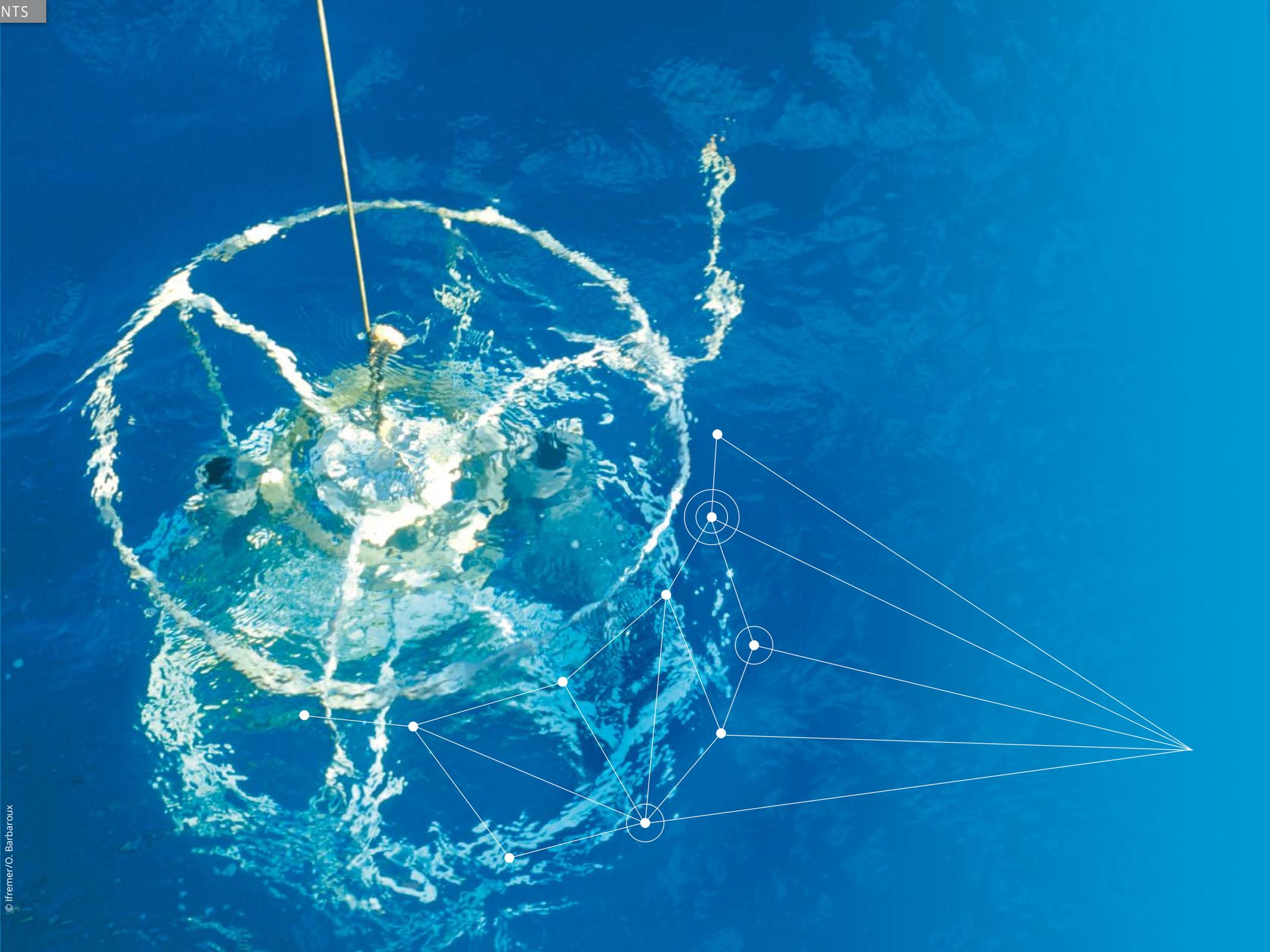
In the framework of the Gigassat project co-financed by ANR, our institute has also explored the links between climate change and the development of Pacific cupped oysters on European coasts, by reconstructing the history of this species’ expansion since it was introduced in France. Studies conducted have shown that the rise in temperature, and in particular, the succession of hot summers since the 1990s, have led to a northward shift in the breeding grounds of Pacific oysters.

As regards fisheries resources, anchovies and sardines have become significantly smaller and leaner in the Mediterranean over the past few years. The EcoPelGol studies co-financed by *France Filière Pêche* (FFP) have highlighted the probable influence of some environmental parameters on fish’s physical condition, and particularly a change in the quantity and/or quality of zooplankton.

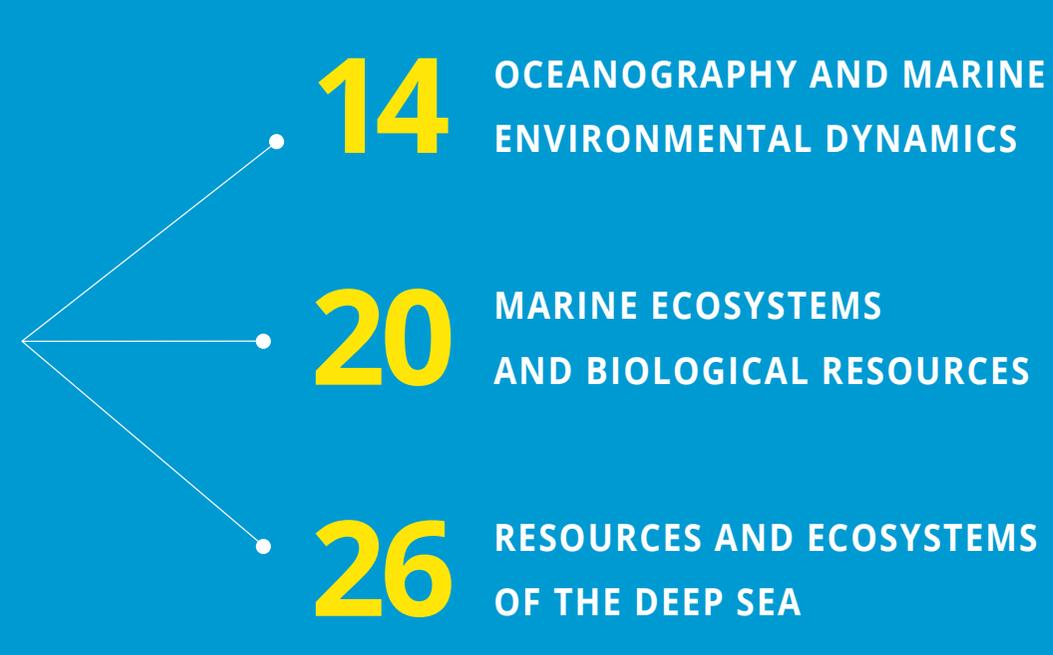
A reef of cupped oysters in Northern Brittany



© Ifremer, C. Dugornay



LIVE
REPORTS
FROM
RESEARCH



OCEANOGRAPHY AND MARINE ENVIRONMENTAL DYNAMICS

Observations in the coastal marine environment... from physics to biology

Observing the coastal environment provides a foundation which is vital for understanding the marine ecosystem. Currently available platforms and sensors enable both continuous and automated collection of a set of measurements for the main physical, chemical and biogeochemical parameters. For over fifteen years, multi-instrumented systems have collected these data along the French metropolitan seafronts.

Building consistent, continuous data sets over long periods, which meet the requirements of research while complying with technical and economic limits, is both a national and European challenge. Rising to this challenge requires harmonising and improving the systems deployed as well as structuring scientific networks. To this end, various initiatives have been undertaken within Ifremer and especially in partnership with CNRS INSU and the scientific community of the marine stations and observatories network (Resomar). These initiatives have particularly led to the I-LICO RI, which includes several coastal environmental monitoring networks, being made an integral part of the national strategy for Research Infrastructures. This infrastructure has a strand devoted to continuous and automated (called high-frequency) monitoring, including various systems deployed by Ifremer which are illustrated here.

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On the national scale, these coastal observations have been used in various scientific studies, including that published by CNRS Editions in 2016, marking the tenth anniversary of the Marel Carnot measurement station, in a book on High resolution measurement in the coastal marine environment.

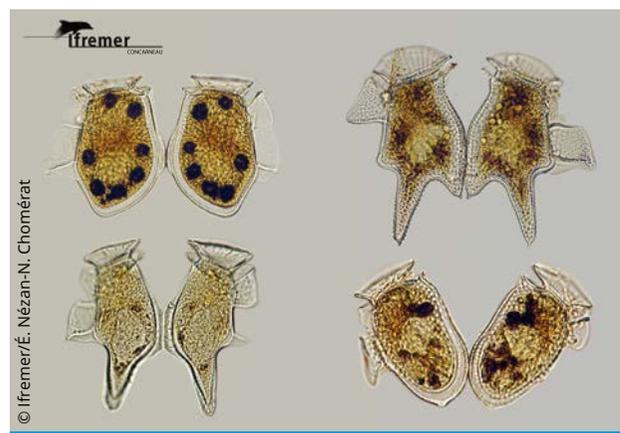
The results obtained based on these observations have advanced our understanding of the dynamics of phytoplankton blooms, thanks to continuous data on chlorophyll concentrations. The outlook for these studies is to combine algae biomass estimations with identification of plankton composition on the scale of taxonomic or functional groups.

Acquiring time series of high frequency measurements has also led to outcomes on methods used to analyse and predict environmental status. In this way, a Markov model analysed using spectral classification methods was developed. It can identify or even predict events such as toxic algae blooms, by taking account of the various (physical and biogeochemical) parameters measured, without prior knowledge of the events analysed.

Studies based on high-frequency monitoring have also demonstrated the importance of intermittent events, and that they have possibly been underestimated. For example, high-frequency observations show that the intrusions of the Rhone river plume in the bay of Marseille are underestimated in numerical approaches, in terms of frequency and amplitude. Moreover, the Rhone shows a significant response to extreme events, but the impact these events have on the different parameters observed can vary depending on local atmospheric and hydrodynamic conditions.

Furthermore, the impact that large-scale trends of the North Atlantic's atmosphere have on inshore waters in the Iroise Sea has been described, showing the probable influence of changes in these atmospheric regimes on coastal physical and biogeochemical conditions.

To go further in understanding these complex coastal systems and their biological component, projects were launched in 2016, including the State-Region Plan contracts for a high-frequency coastal environmental monitoring network (ROEC) and Marine and coastal research on the Côte d'Opale: from environments to resources, to the use and quality of aquatic resources (Marco). Both projects aim to develop monitoring systems giving access to new (particularly biological and hydro-sedimentary) parameters to better understand coastal ecosystem dynamics. For instance, the ROEC network will focus special attention on bottom dynamics



Dinoflagellates, toxin-producing microalgae



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Iroise Marel buoy at Ifremer's Brittany centre

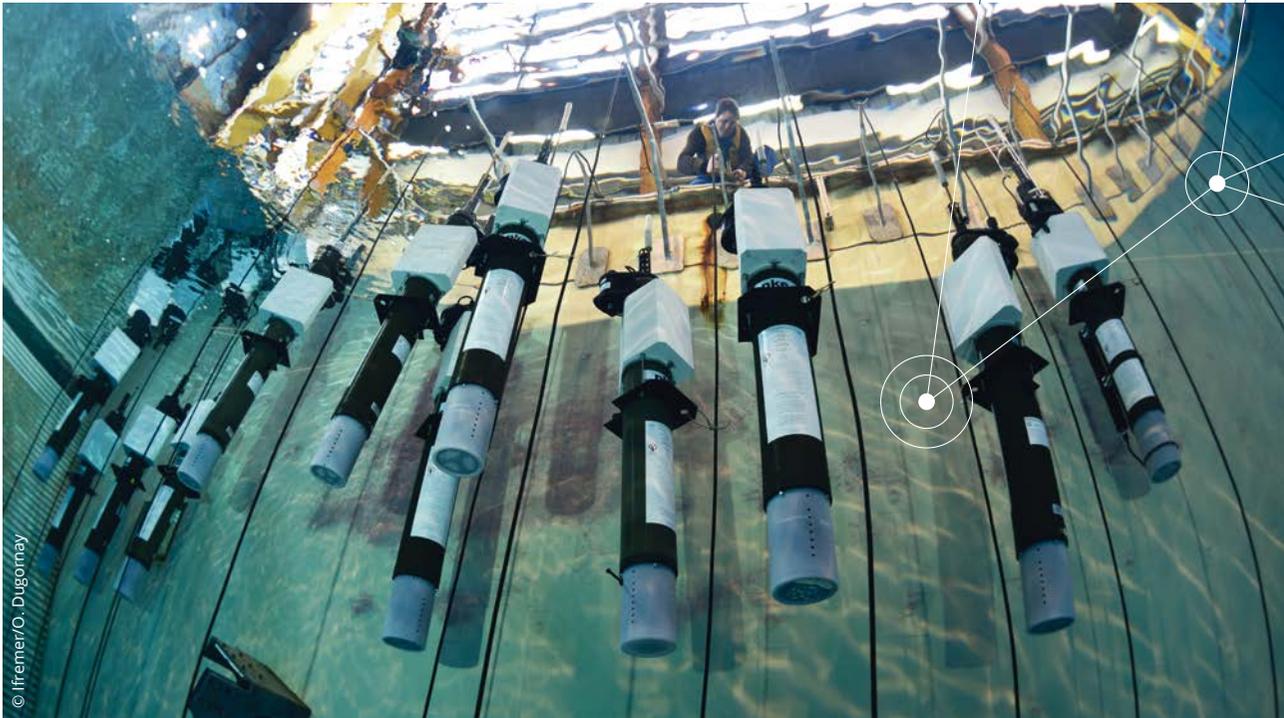
in terms of oxygen concentrations, sedimentary transport and plankton diversity in the waters around Brittany.

On the European scale, Ifremer coordinates various initiatives aiming to integrate and open up research infrastructures of interest for Europe. As for coastal observation systems, the actions take the form of coordinating Joint European Research Infrastructure Network for Coastal Observatory – Jerico (programme FP7, 2007-2011) and Jerico-NEXT (H2020 programme which began in 2016) projects.

Above and beyond their organisational and harmonisation role, these European initiatives also enable technological and scientific progress to be made. The major outcomes of Jerico were published in a special issue of the *Journal of Marine Systems*. Technological (observation of macrofauna, zooplankton, carbon cycle and pH measurements) and methodological (data assimilation) developments and the scientific progress made possible thanks to the infrastructures supported by the project, have improved our understanding of coastal dynamics in the Bay of Biscay, the Algerian basin and the Baltic Sea.

Beyond the scientific and technological advances associated with these coastal monitoring observation networks, Ifremer is participating in the strategy and structuring of future monitoring networks. Optimising future integrated monitoring systems is proving to be increasingly complex, since it involves many environmental (and even economic) parameters in a limited coastal area. To tackle this complexity, optimisation methods inspired by data assimilation techniques in oceanographic models are being developed at Ifremer in cooperation with CNRS/INSU. They will provide an objective and partially quantitative assessment of the existing observation networks and of the proposed developments.

PUILLAT I. et al., 2016. *Journal of Marine Systems*. <http://dx.doi.org/10.1016/j.jmarsys.2016.06.004>
SCHMITT F.G. & LEFEBVRE A. (Eds.) 2016. *Mesures à haute résolution dans l'environnement marin côtier* (HR measurements in the coastal marine environment), CNRS Editions. <http://doi.org/10.17882/39754>
GUESDON S. et al., 2016. *Estuarine, Coastal and Shelf Science*. <http://dx.doi.org/10.1016/j.ecss.2016.08.035>



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Testing drifting ocean (automatic profiling) floats

Fifteen years of ocean observations with Argo

In 1999, the international community of physical oceanography researchers initiated the setting up of one of the most ambitious scientific programmes in the field's history. The systems existing at the time were indeed insufficient for 1) studying the ocean's variability and its role in the climate; 2) interpreting the surface measurements taken by satellite and 3) improving numerical models and developing operational oceanography. This was the advent of Argo: an *in situ*, large-scale and real-time global observation network using automated drifting floats (supplying temperature and salinity profiles). Fifteen years later, Argo is operational and now supplies the major part of ocean

observations at depths between 0 and 2,000 metres. Argo data have led to accurate quantification of seasonal and interannual variability in the ocean's heat content. Even more emblematically, Argo data have significantly reduced uncertainty about the fact that over 90% of the heat accumulated on Earth between 1971 and 2010, principally due to the intensification of the greenhouse effect, was stocked in the ocean. Argo also made it possible to demonstrate that global warming of the ocean contributed (through thermal expansion) to one third of the rise in sea level observed between 1993 and 2010. The data from Argo can be used to determine overall mean values, but more especially still, regional values, which enables better comprehension of regional climate changes.

In 2016, Ifremer remained a major stakeholder in the network at every level. Technological developments of profiling floats have grown their capabilities, especially for very deep measurements using Deep-Arvor. The Coriolis centre has continued to purchase, implement and monitor profiling floats, with fifty-five new floats deployed. Data processing has benefited from the publication of international procedures specific to oxygen data and the constant improvement of validation methods. Lastly, French research scientists contribute to 10% of scientific publications using Argo data: thus, Ifremer and our partner institutes involved in the French component of Argo help spread the international influence of the French oceanographic community. To do so, SNO Argo France, steered by LOPS (Physical and spatial oceanography laboratory, UMR CNRS-Ifremer-IRD-UBO joint research unit), facilitates the community (June 2016 symposium in Toulon) and takes part in the international governance organisation of the Euro-Argo network.

LE RESTE S. *et al.*, 2016. *Journal of Atmospheric and Oceanic Technology*. <http://dx.doi.org/10.1175/JTECH-D-15-0214.1>
 RISER S.C. *et al.*, 2016. *Nature Climate Change*. <http://www.nature.com/nclimate/journal/v6/n2/full/nclimate2872.html>

INTERVIEW



Philipp HESS
 RESEARCH SCIENTIST AT THE PHYCOTOXINS
 LABORATORY, IFREMER

DEPUTY DIRECTOR OF THE IUML UNIVERSITY
 INSTITUTE FOR SEA AND COAST
 (CNRS-UNIVERSITY OF NANTES-IFREMER)

The proliferation of some species of single-celled microalgae (phytoplankton) in blooms which sometimes colour the water brown, red or green, can be toxic for fish and shellfish. In humans, consumption of contaminated shellfish can cause gastrointestinal or even neurological symptoms. The toxins produced by these microalgae are called phycotoxins.

Are there as many toxins as there are toxic microalgae?

No. A species (or genus) of toxic microalgae can produce several types of toxins. More than 5,000 microalgae are known, of which 174 species are toxic or harmful (they are described in our book*). It is important to watch for and predict potential proliferation, called blooms, of marine phytoplankton by regular monitoring and systematic analyses (set up all along the coast in France and elsewhere in the world) and of course, to identify the toxins which are present in sea water.

We have listed over five hundred toxins worldwide, and the number of toxins observed is growing. Indeed, maritime shipping has increased the inputs of "exotic" species via bal-

last water. Climate change and the phenomenon of coastal water warming also foster their proliferation in subtropical and temperate zones.

You're developing a new approach to analyse toxins. What makes this method innovative?

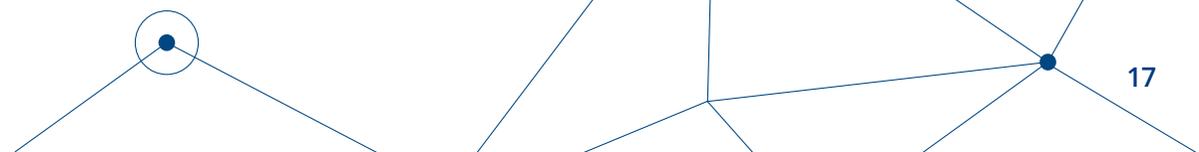
The official analytical method used is based on mass spectrometry. This quantitative method is targeted at molecules which are known to be toxic. But for lipophilic toxins, only twelve molecules are tested.

In the framework of the regional Coselmar project, we have demonstrated the feasibility of a new method¹ combining two techniques: 1) passive sampling and 2) high resolution mass spectrometry. The first technique makes it possible to accumulate all the lipophilic compounds dissolved in sea water, a sort of "chemical fingerprint" left by microorganisms (including microalgae), while the second one simultaneously measures a huge number of chemical compounds without having to target a given molecule (non-target screening analysis). In this way, we can detect a large number of dissolved compounds, and particularly algal toxins. Once the data

is acquired, we screen our database to see if one or another of the 500 toxins inventoried worldwide might be present. These are early days for our research in this field, because few of the metabolites produced by microalgae are known. Many other emerging organic compounds and toxins remain to be discovered in marine and brackish environments.

¹ ZENDONG Z. *et al.*, 2016. *Environmental Science & Technology*. <http://pubs.acs.org/doi/ipdf/10.1021/acs.est.6b02081>

* see next page



Toxic and Harmful Microalgae of the World Ocean

Micro-algues
toxiques et nuisibles
de l'océan mondial



PATRICK LASSUS · NICOLAS CHOMÉRAT
PHILIPP HESS · ELISABETH NÉZAN

Blooms of toxic microalgae have increased in every ocean of the world in past decades. That is the conclusion reached by the authors of a bilingual book (*) which lists 174 species and the toxic episodes related to them, after analysing over 1,200 scientific publications. For the first time, information about the taxonomy, geographic distribution of each species, cases of toxicity and their chemical nature has been gathered in a single publication. Each species is illustrated with photos of exceptionally high quality taken with photo-scanning and electron-scanning microscopy.

(*) "Toxic and Harmful Microalgae of the World Ocean/
Microalgues toxiques et nuisibles de l'océan mondial"
by Patrick LASSUS, Nicolas CHOMÉRAT, Philipp HESS
and Elisabeth NÉZAN
IOC Manuals and Guides, bilingual publication, Ed.
www.issaha.org

Thirty years of iceberg climatology in the Southern Ocean using satellite altimetry

The loss of volume of the Antarctic icecap in the form of fresh water fluxes towards the Southern Ocean follows two radically different pathways. Water from basal melting of floating ice shelves is distributed over the first few hundred metres in coastal waters, whereas some icebergs calved from glaciers and floating shelves drift over thousands of kilometres and melt far from the mainland. Therefore, these fresh-water fluxes play a vital role in both inshore and offshore circulation in the Southern Ocean. Recent studies using satellite measurements and snow accumulation models yielded very similar estimations of basal melting, with respectively ~ 1,500 gigatons per year and calving with ~ 1,300 gigatons per year. A change in the distribution of fresh water fluxes between melting and calving could have repercussions on the global climate system. Indeed, although basal melting only affects along-shore hydrology, icebergs can influence the ocean quite far from the zone they come from.

Satellite altimetry makes it possible to detect and estimate the volume of small (< 3 km) and large (> 16 km) icebergs. A database of ice location and volume data covering all archives for all altimeters (1985-2016) was created in the framework of Altiberg 1 and 2. It is distributed by Cersat. Analysis of ice volumes in the Southern Ocean shows that over a thirty-year period, variability in the volume of ice present mainly depends on sporadic calving events of giant icebergs (some of them exceeding 1,000 km²), which can travel for ten years around the Antarctic continent. Most of the ice volume is transported by the largest icebergs, but their melting only represents 18% of the total loss of volume. Their breaking into small icebergs is the principal mechanism of mass transfer conditioning the flow of fresh water towards the ocean. Thus, small icebergs act as a diffusion process and make up the most efficient component of the fresh-water flux.

TOURNADRE J. *et al.*, 2016. *Journal of Geophysical Research-Oceans*.
<http://doi.org/10.1002/2015JC011178>

A tabular iceberg drifting in the Southern Ocean



Trawling's contribution to sedimentary fluxes on the continental shelf of the Bay of Biscay

The spatial-temporal variability of sedimentary fluxes under the influence of natural forcings and trawling activities was studied on the scale of the continental shelf of the Bay of Biscay by combining data from ocean research cruises and deterministic 3D numerical modelling. Two specific cruises were conducted to quantify the physical impacts entailed by a professional vessel's trawl in the Grande-Vasière mud flat area, in terms of resuspension (turbid plume) and disturbance of the structure and nature of the surface sediment. The data were used to estimate the mean rate at which sediments were eroded by the trawl. These observations, supplemented by data on the fishing effort, provided a monthly map of erosion fluxes due to trawling. In addition, a realistic 3D hydro-sedimentary model was implemented and calibrated with fixed station measurements. Two five-year simulations were run, with or without the influence bottom trawling, to quantify and compare the relative contributions from natural and anthropogenic forcing on vertical (erosion) and horizontal (solid transport) sediment fluxes. The variability of fluxes over time is described as a succession of characteristic regimes in response to various forms of forcing (tide, wind, waves, trawling), and seasonal and annual residual fluxes have been suggested. Without taking riverine inputs into account, the natural flux of muddy matter was estimated at 1.6 million tonnes (or megatons) yearly flowing out to the North (to the right of the Raz headland) and at 0.62 million per year towards the foot of the continental slope (at the 180-m isobath). These fluxes are similar in volume to the river inputs (approximately 2.5 megatons per year). Bottom trawling significantly contributes to resuspension and leads to significant horizontal fluxes which are part of the regional sedimentary dynamics on the shelf. These fisheries activities particularly increase the natural export of fine sediments seaward on the outer part of the shelf (from 15 to 35%). They significantly contribute to North-westerly fluxes and can also result in residual fluxes towards shore on the inner part of the shelf.

MENGUAL B. et al., 2016. *Ocean Dynamics*.
<http://link.springer.com/article/10.1007%2Fs10236-016-0974-7>

Ecological restoration in the Mediterranean Sea

Shoreline artificialisation and habitat destruction in shallow coastal waters are amongst the principal forms of pressure exerted on marine ecosystems, especially in the Mediterranean. In this way, the construction of harbours and marinas has led to the destruction of more sheltered habitats which are used as nurseries by numerous fish species. However, although the negative ecological impact of these constructions has been widely documented, their potential role in the coastal zone's functioning remains poorly known.

Within this context, the action called Response (restoring nursery functions in harbours) is trying to verify whether artificial structures located inside harbours can be used by fish as nurseries. Preliminary studies have demonstrated the relevance of bio-indicators concerning the density, growth and condition of juveniles to estimate the quality of fish nurseries.

Spatial and temporal variability in the abundance of juveniles of four species of rockfish was monitored over two years in five Mediterranean harbours. The benefit of adding artificial micro-habitats to the potential nursery function of harbour structures like quays or floating pontoons was also tested. The results show that despite differences between the species in their habitat preferences, juveniles of rockfish very significantly colonise the harbours. Their abundance on artificial micro-habitats added was twice as high as on bare structures. This suggests that rendering harbour structures more complex can considerably improve their quality as a habitat for juveniles, particularly in the youngest phases.

Furthermore, an integrated study linking the chemical quality of the environment to its impact on juveniles of these same species was carried out in the harbour



© M. Bouchoucha

Artificial habitats made of oyster shells, placed in the harbour area of the bay of Toulon, for use by juvenile fish

areas of the Bay of Toulon (Var) which is known for its high levels of contamination. Quite unexpectedly, despite the higher levels of contamination found both in the environment and in organisms, the results obtained show that the growth and condition of juvenile individuals caught in harbour areas are equivalent to or even better than those observed in natural areas.

These studies, carried out in collaboration with Cefrem and UMR Marbec, suggest that if environmental conditions are compatible and controlled, ecological engineering in harbour areas could help reduce some ecological consequences of urban development by providing alternative artificial nursery zones for rockfish.

BOUCHOCHA M., 2016. *Marine Ecology Progress Series*.
<https://doi.org/10.3354/meps11641>

MARINE ECOSYSTEMS AND BIOLOGICAL RESOURCES

Better understanding diseases affecting marine molluscs

European shellfish farming holds a prominent position on the global scale. The activity is mainly based on farmed mussels, oysters and clams and has a significant socio-economic dimension, with 42,000 people employed by more than 8,500 companies in Europe. In recent years, the sector has experienced slower growth, particularly because of its dependence on environmental quality and the emergence of diseases. Indeed, the value chain has been weakened by massive mortality episodes associated with the presence of various pathogenic organisms, whether viruses like OshV-1, bacteria like *Vibrio aestuarianus* or parasitic protozoa such as *Marteilia refringens* or *Bonamia ostreae*. These events have led to serious economic losses.

Ifremer is developing research activities at the core of these issues and coordinating the monitoring of shellfish diseases.



The Institute leads the missions of the national reference laboratory (LNR) and European Union reference laboratory (EURL) tasked for mollusc diseases and is an international referent for the OIE world organisation for animal health for some shellfish diseases, including bonamiosis, marteiliosis and OsHV-1 viral infections.

Along with its involvement in monitoring and referent activities, Ifremer carries out research studies aiming to better characterise pathogenic organisms and better understand the cycle of their development and their interactions with their hosts, i.e. bivalve molluscs. These studies have notably enabled diagnostic tools to be developed and experimental infection protocols required to study the mechanisms of infection and the mechanisms of defence that shellfish develop to be perfected. The results obtained lead to modelling the transmission of certain pathogenic organisms. Recognised for its position as a reference in Europe in the framework of its studies on shellfish diseases, Ifremer has brought together twenty-one public- and private-sector partners in the European Vivaldi consortium, selected in 2016 in a call for H2020 projects.

The prime objective of this project is to improve the sustainability and competitiveness of the European shellfish farming sector by developing tools and approaches to better prevent and control diseases in marine bivalve molluscs. Vivaldi is looking at various species of bivalves farmed or

harvested in Europe, like cupped and flat oysters, mussels, Manila clams, cockles and king scallops. The diversity of shellfish farming sites is also taken into consideration, with studies planned on contrasting sites like the Ebro delta and the Vigo ria in Spain, the bay of Brest in France and the bay of Dungarvan in Ireland.

Vivaldi is broken down into six work strands:

- studying the diversity and cycles of pathogenic organisms for better monitoring and development of early detection tools;
- understanding bivalves' functional response in order to develop prevention methods and treatments;
- genetic selection for resistance/tolerance to certain diseases;
- understanding the complex interactions between molluscs, the environment and the pathogenic agent to better assess risks, and developing risk prediction models;
- measures to manage some diseases and biosafety;
- a better grasp of how the shellfish industry is organised, to better manage diseases.

Since shellfish diseases know no borders, an international network of experts from the main shellfish producer countries is being established.

In terms of research, Vivaldi aims to deliver new knowledge about the diversity of pathogens, immune responses in shellfish and interactions of animals and pathogenic agents with their direct surroundings. Furthermore, through both improved knowledge about the stakeholders in the shellfish sector and the knowledge supplied by researchers, the project aims to better support policy-makers in their role of regulation and support for these value chains. Finally, Vivaldi also intends to make its contribution to a European science without borders, thanks to joint publications, sharing equipment, comparing experiences mutually informing each other on a regular basis about shellfish diseases.

4 YEARS OF RESEARCH
 FROM 1 MARCH 2016 TO AU 28 FEBRUARY 2020

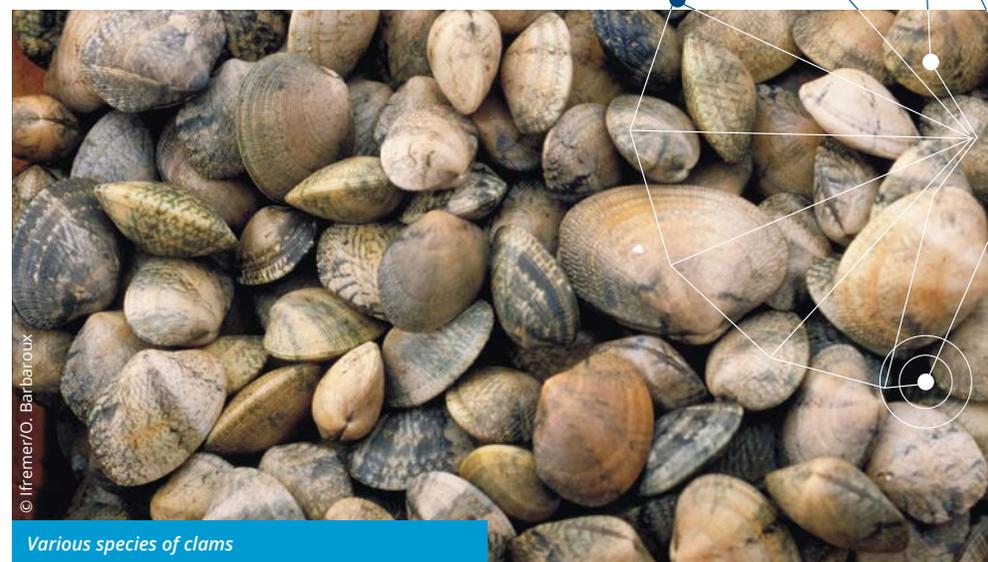
RESEARCH SCIENTISTS AND TECHNICIANS INVOLVED

21 PARTNERS

10 COUNTRIES
 8 EUROPEAN UNION MEMBER STATES, JOINED BY NORWAY AND ISRAEL

4.5 MILLION EUROS OF EU FUNDING

7 SPECIES OF SHELLFISH STUDIED



© Ifremer/O. Barbaroux

Various species of clams

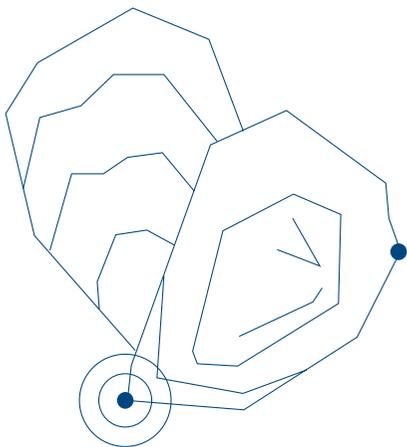


© Ifremer/S. Pourreau

A natural bed of wild *Crassostrea gigas* oysters

Climate change and invasive cupped oysters on European coasts: spatial projection of colonisation

Originally from Japan, the cupped oyster *Crassostrea gigas* was introduced in the late 1960s in the Arcachon and Marennes Oléron basins, in a context when the Portuguese cupped oyster *C. angulata* was nearly disappearing from the Atlantic coast. According to the climate data at the time, *C. gigas* did not have the ecological ability to reproduce further north than the Loire River, seeing the temperature requirements for spawning and survival of its larvae. Half a century later, it now successfully breeds up to the south of Norway and in some environments with particularly favourable hydrodynamic conditions, it creates actual marine reefs.



A study called Gigassat, conducted in the ANR framework and based on their eco-physiology, enables us to explain the unexpected dynamics of this invasion on the scale of Europe. Its novel methodology is based on the combined use of: 1) a DEB (dynamic energy budget) type bioenergy model which makes it possible to formalise how an organism uses the energy it draws from nature for its growth, or reproduction for instance. This model is implemented at Ifremer and has been tried and tested on *C. gigas* for several years; 2) long-term biological series produced by Ifremer networks: the shellfish farming observation network (Resco), the cupped oyster reproduction and recruitment observation network (Velyger) and phytoplankton data from the Réphy network and 3) satellite surface-water temperature data available on the scale of Europe. First, simulations of reproduction in the species

were validated, from 1998 to present, for the bay of Bourgneuf (Vendée region). Next, the exercise consisted in using a model of this bay since 1960 and spatially extending its application over all of Europe.

This broad-scale study showed that the rise in temperature and the succession of hot summers since the 1990s have brought about a northward shift of more than 1,400 km in the species' breeding niche area in nearly forty years' time. The study also delivers, in terms of methodology, a novel generic approach which is applicable to other species or other systems, thus making it possible to analyse potential changes which could affect the biogeography of marine species in the context of climate change.

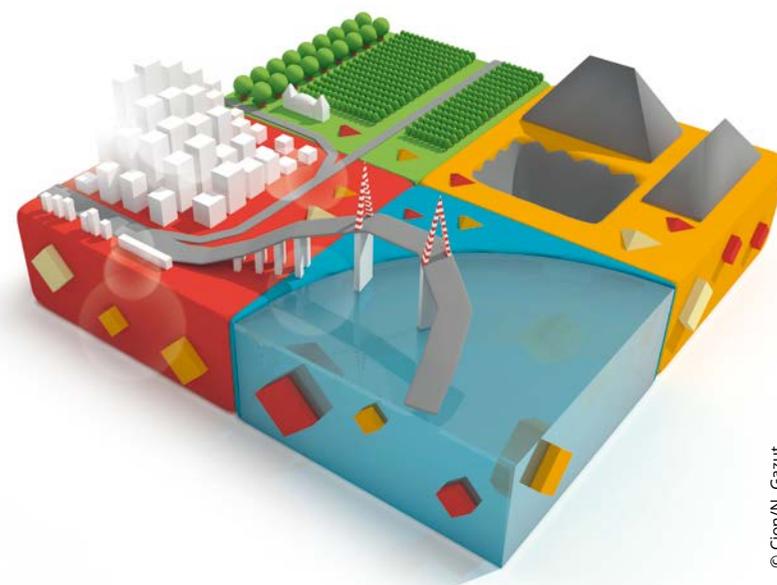
THOMAS Y., 2016. *Journal of Biogeography*. <http://onlinelibrary.wiley.com/doi/10.1111/jbi.12665/abstract>

Pollusols

In the framework of the Pollusols (2015-2019) project financed by the Pays de la Loire regional council, University of Nantes and Ifremer, several research teams are studying diffuse metallic pollution, from their sources on land (mines, cities, cultivation of fruit trees and vine-growing) to the Loire estuary. For this programme, four study-site zones were determined in its novel approach encompassing the land-sea continuum. Its final objective is to propose tools to manage polluted sediments and soils.



The estuarine contaminants studied by Ifremer are metals such as platinoids (emergent substances), mercury, lead and copper (an essential trace element, it becomes toxic at high concentrations). Studies on chemical speciation and isotopic signatures of these three groups of elements enable their pathways and changes over time related to global change or regulations in effect to be monitored. Thus, Ifremer is contributing to the project, both through studying contamination of the ultimate receptacle (i.e. the sea) of contaminants coming from the three study zones examined (city, vineyards and mine), as well as by structuring all the investigations conducted in the Loire estuary, which is the fourth study zone. The programme should make it possible to obtain some explanation for the sharp rise in copper concentrations in bivalve molluscs collected on some sites in the Atlantic Ocean, as well as to better quantify the continental and marine proportions of the mercury accumulated in coastal food webs, and finally, to document the emergence of platinoids.



© Cion/N. Gazut

Stylised illustration of experimental sites for Pollusols: urban, uranium mine, vineyard and estuary (Loire)

Developing trophic indicators in the framework of an ecosystem-based approach to fisheries

Marine ecosystems are subjected to various forms of pressure, the strongest being the fragmentation of habitats, fisheries, pollution, eutrophication, the introduction of invasive species and global warming. These pressures create changes in the structure and dynamics of ecosystems. In marine ecosystems, the impact of fisheries is often the predominant factor of pressure. In this context, there is a need for simple indicators to assess the environmental status of marine ecosystems. These indicators must reflect the effects of fluctuating fishing pressure and be easily implemented in an ecosystem-based approach to fisheries management.

Therefore, various indicators have been calculated, based on size or weight structures and trophic levels of different communities of species, based on scientific cruise data and simulations produced by food web models. The way the different indicators respond to management scenarios show that all the trophic indicators selected are sensitive to fishing pressure. Two of them: the highest trophic level indicator (HTI) and the Apex Predator Indicator (API), show promising leads for assessing the status of an ecosystem. Thus, a range of management scenarios and target values for the indicators tested can be proposed. Lastly, sensitivity analyses highlight the importance of the choice and the accuracy of trophic level estimations in calculating indicators using data from scientific cruises.

BOURDAUD P. *et al.*, 2016. *Ecological indicators*. <http://dx.doi.org/10.1016/j.ecolind.2015.10.010>

EcoPelGol project

Whereas in 2005-2007, the situation for anchovies and sardines in the Mediterranean seemed ideal, it has deteriorated substantially since 2008. Individuals of these two species are now smaller and leaner, along with displaying a lower age at catch and decreased growth in sardines. Concurrently, a sharp rise in the sprat population (a species with low market value) has been observed over the same period. These changes have created a major and unprecedented crisis for French fisheries in the Mediterranean. Catch levels have dropped ten-fold in a few years' time, reaching their lowest levels

ever for the past 150 years, as shown by a reconstitution and analysis of landings since 1865.

In an exhaustive analysis of physical condition, growth rates and age and size structures of these species, obtained via data from Pelmed (*Pélagiques Méditerranée*) scientific cruises and fisheries data, the EcoPelGol project examined the processes underpinning these modifications. EcoPelGol is co-financed by the *France Filière Pêche* (FFP) sector-based organisation and was carried out with the UMR Marbec joint research unit in partnership with the University of Girona (Spain) and UMR MIO

(Mediterranean Institute of Oceanography, University of Aix-Marseille-University of Toulon-CNRS-IRD).

The EcoPelGol project has shown that the changes in size and condition in sardines and anchovies were linked neither to the migration of individuals towards adjacent geographic zones, nor to fishing pressure, nor to predation by tunas or marine mammals. Although infectious diseases do not seem to be the cause of these modifications either, additional studies are being conducted on the presence of hepatic parasites. However, other analyses have shown the probable influence of some

environmental parameters on the fish's physical condition. In fact, the diet of sardines and anchovies has evolved over the past few years towards smaller-sized prey which are potentially less nourishing. The older individuals were probably not in sufficiently good condition to ensure their survival after breeding, which could explain the demographic changes observed in the sardine population. All indications seem to point to a change in the quantity and/or quality of zooplankton (prey) as the prime cause of modifications recently highlighted in populations of small pelagic fish.



Trawling and sorting of small pelagic fish in the Mediterranean, Pelmed cruise

INTERVIEW

Recently, on behalf of Ifremer, you filed several patents protecting molecules and, more accurately, derivatives of exopolysaccharides (sugar polymers) as wound-healing and anticancer agents. These exopolysaccharides (EPS) are characterised by the fact that they are produced by marine bacteria which Ifremer discovered at depths greater than 2,000 metres during deep-sea exploration cruises.

What are the characteristics of these bacteria?

Ifremer has a collection which is unique worldwide of microorganisms from extreme marine environments, particularly comprising EPS-producing bacteria from known genera, such as *Vibrio* and *Alteromonas*, as well as new species like *A. infernus*. The latter species comes from cold seeps (from 9 to 18° C, pH 6.7), observed to the north of the Guaymas basin (East Pacific). This mesophilic (organism which grows in moderate temperatures) bacteria is cultured in the laboratory at ambient temperature in glucose-enriched sea water to produce an EPS with a high molecular weight (several million grammes per mole). EPS is an acidic heteropolysaccharide which is water-soluble. The molecule, made up of nine repetitive osidic units (sugars), is slightly sulfated (9%). This is rare and gives it properties similar to those of glycosaminoglycans (GAG), which are polysaccharides from animal and human tissues studied for the major role they play in regulating cell activity and which hold significant therapeutic potential.

What is Ifremer's role in research on the biological activities of these EPS?

Firstly, in the laboratory, it consists in managing our collections of bacteria, verifying their purity while checking their identity, then creating working banks from primitive strains. Production of EPS at various scales, as well as their purification and characterisation, are also part of studies developed at Ifremer. To optimise this production, these EPS mechanisms of bio-

synthesis are analysed in physiological and genetic terms. To perfect their resemblance to GAG (heparin, hyaluronic acid, etc.) and obtain GAG-mimetic EPS derivatives, the EPS are modified in the laboratory using different processes: depolymerization, over-sulfation. The different GAG-mimetic derivatives are characterised before being studied by our partners to assess their biological properties and their benefit/risk ratio, comparing them against known therapeutic agents for reference. Studies on health-related applications for EPS derivatives are being developed in partnerships within various regional, national and European projects (Cimath, Bioregos, Bioregate, GlycoOuest, ANR Ionibogel, GdR GagoSciences, Interreg Biocare marine).

Working with the University of Nantes (UMRS Inserm 957) in the framework of the GlycoOuest network, we have recently shown that an EPS derivative presents an inhibiting effect on cancer invasion and the process of metastasis, without any apparent effect on the primitive tumour. The effects obtained with the EPS derivative are greater than those obtained using the reference molecule, heparin.

Do bacteria which usually live in "extreme environments" keep their properties over time?

Bacteria which come from the abyssal plain have been conserved in the laboratory for nearly thirty years. They have kept their initial characteristics and still produce the same



Sylvia COLLIEC-JOUAULT

RESEARCH SCIENTIST AT THE MICROBIAL ECOSYSTEMS AND MARINE MOLECULES FOR BIOTECHNOLOGIES LABORATORY (EM3B)

EPS. The genome of some bacteria has been fully sequenced, which, thanks to molecular biology tools, makes it possible to perform comparative analyses. Biosynthetic EPS clusters are currently being identified.

Are you looking at other bacteria from the deep sea?

The *Vibrio diabolicus* bacteria also displays great potential in the fields of cosmetics and health. Its genome has been sequenced and a PhD thesis studied the cloning of biosynthetic EPS clusters in *Escherichia coli*. These studies pave the way for biotech production of this EPS, which is an analog of the hyaluronic acid widely used in cosmetics.

Our culture collection hasn't revealed all its treasures yet and some fine discoveries are still in store!

RESOURCES AND ECOSYSTEMS OF THE DEEP SEA

Exploring hydrothermal vents

Technological advances and the advent of exploratory submersibles in the early 1960s made it possible to acquire fundamental knowledge about how the deep ocean functions, with the discovery of life in the absence of light, thanks to chemosynthesis. Since then, scientific exploration has identified different types of environments and mineral or biological resources which are arousing increasing interest in a context linked to increasing scarcity of continental resources, climate change and anthropogenic impacts.

Hydrothermal vents are located at great depths and associated with distinctive ecosystems whose functioning remains little known. The potential development of activities to exploit these resources is reviving activities for exploration and requires that the question of their impact on ecosystems be raised beforehand. This is the case of ecosystems related to fluid circulation.

New hydrothermal mineralisation

Three cruises devoted to exploring the exclusive economic zone (EEZ) of Wallis and Futuna (Futuna 2010, 2011 and 2012) highlighted a very extensive active hydrothermal zone, thanks to a systematic approach of making chemical and physical measurements in the water column. The outcomes of these analyses were published in 2016 and highlighted exceptional chemical diversity. The observations showed the importance of volcanic zones linked to the subsidence of plates, just like the ridge zones, in hydrothermal circulation and for overall biogeochemical cycles.

These exploratory studies identified numerous active and fossil hydrothermal zones and discovered a new type of hydrothermal mineralisation hitherto unknown in oceans. These mineralisations made up of manganese, located in the French EEZ of Wallis & Futuna Islands, are abnormally enriched in nickel, cobalt and copper at levels equivalent to those found in polymetallic nodules and even exceeding the concentrations recorded in ferromanganese crusts. Studies conducted on these deposits lead us to reassess the significance of low-temperature hydrothermal processes in the transfer of metals from the lithosphere to the hydrosphere and require that the “classic” schemes to identify oceanic iron-manganese deposits be entirely reconsidered.

KONN C. *et al.*, 2016. *Deep-Sea Research*. <http://dx.doi.org/10.1016/j.dsr.2016.07.012>



© Ifremer - Nautile/Campagne Futuna

Black smoker

Understanding how hydrothermal ecosystems function

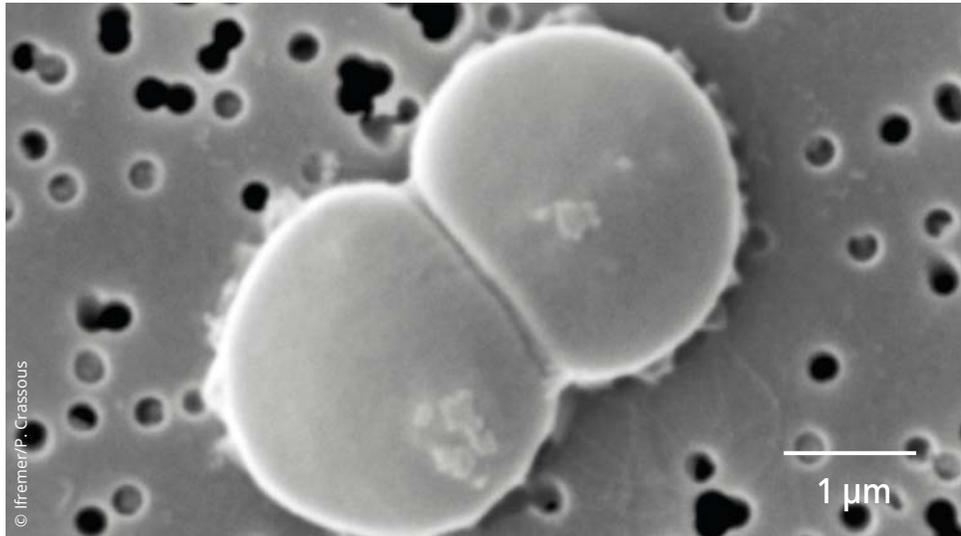
Although we are beginning to be quite familiar with the various components of hydrothermal ecosystems in terms of biotope and fauna, the role and success of the dominant species there are still poorly understood.

Rimicaris exoculata belongs to a family of shrimps which inhabit chemosynthetic environments all over the world, called Alvinocarididae. These shrimp colonise sites on the Mid-Atlantic Ridge at depths between 1,700 and 4,000 metres. It is one of the organisms in these special deep-sea habitats which has been the most studied. However, many questions about its biology remain. Despite the numerous specimens obtained since 1986, when the species was described for the first time, its life cycle and early stages of larval development remain practically unknown. A detailed morphological description of larvae from four species in this family, including *R. exoculata*, was made immediately following the hatching of their eggs. By comparing them with the larval features of other families of shrimp in deep-sea environments, some biological larval traits which are important for the dispersal of the species have been highlighted. The larvae of the four species studied effectively all display the same combination of features indicating a long larval development phase, with a larva which, in the initial stage, does not feed on plankton, but rather uses its own reserves. This original combina-

tion of traits is currently unknown in any other deep-sea shrimp family. This may represent a key evolutionary feature of the alvinocaridids, enabling them to successfully disperse as larvae and stay in chemosynthetic habitats in the deep environment.

The mussel *Bathymodiolus azoricus* is another iconic species of the deep-sea floor. It is the dominant species on the active sites of the Lucky Strike vent field on the Mid-Atlantic Ridge. The biomass there is dominated by this bivalve mollusc which probably plays a fundamental role in the ecosystem's functioning. The data acquired during oceanographic cruises (particularly on the Exomar 2005, Momareto 2006, Momarsat 2011 and 2014 cruises), processed using novel statistical analysis approaches, enabled the thermal niche of seventy species found in faunal assemblages of the “Eiffel Tower” edifice to be characterised. The biomass and density of *B. azoricus*, and the fauna associated with it, were compared using different samples in order to understand their distribution with respect to environmental conditions: the mussels supplied up to 90% of the biomass, thus proving that *B. azoricus* acts as a foundation species; their spatial distribution depends on their size. The study confirms a gradual change in community structures along the mixing gradient between sea water and hydrothermal fluids. The analysis revealed the limits of thermal ranges in which species are observed, specifying the taxa which share the same thermal niche. In this way, the study provides the basis for a future ecosystem-based model.

HERNANDEZ-AVILA I., *et al.*, 2015. *Plos One*. <http://dx.doi.org/10.1371/journal.pone.0144657>
 HUSSON B. *et al.*, 2017. *Deep-Sea Research Part II*. <http://dx.doi.org/10.1016/j.dsr2.2016.05.028>



Archaea, *Pyrococcus abyssi*, cell in division, scanning electron microscopy

Near hydrothermal vents, the Pasteur institute and Ifremer have discovered an evolving connection between DNA transcription and replication

The mechanism of DNA replication has been conserved throughout all realms of life forms. DNA polymerases are one of the key actors, as enzymes playing a part in the replication and repair of DNA. As for RNA polymerases, they are involved in RNA synthesis.

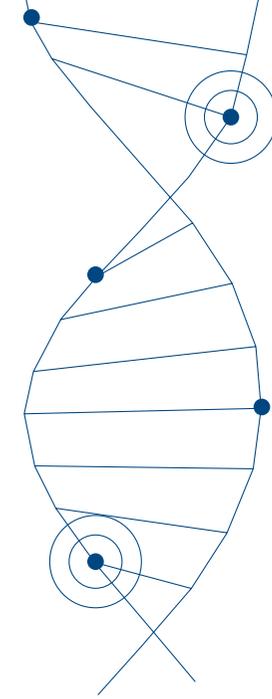
The family D of DNA polymerases (PoID) was discovered in 1997 in Japan, when a DNA polymerase was identified in *Archaea* (single-celled microorganisms which are different from bacteria). Classified as a new

DNA polymerase family (Family D), PoID has undergone numerous biochemical characterisations by international teams, including UMR LM2E (Extreme environment microbiology laboratory, Ifremer-CNRS-UBO).

Like all DNA polymerases isolated from microorganisms living in high temperatures, this molecule is a brand-new target for biotechnology applications. The PoID gene sequences in the hyperthermophilic hydrothermal *Archaea* model species (*Pyrococcus abyssi*) and its functional properties which may hold valuable potential led Ifremer to file a patent (2000-2011). Although this enzyme is not in the catalogues of molecular tools yet, the UMR LM2E joint research unit has demonstrated that PoID is active in DNA amplification. Thanks to the tenacity of many researchers and the deve-

lopment of high-throughput crystallization platforms, the X-ray diffraction structure of two subunits of PoID at high resolution was obtained in 2016 at the Pasteur institute. Surprisingly, the architecture of the catalytic core of the large subunit is similar to that of RNA polymerases. These results have demonstrated, for the first time, an evident connection between the RNA realm and that of DNA with an enzyme, DNA polymerase of *Archaea*, evolutionary evidence of the polymerisation of nucleic acids.

SAUGUET L. *et al.* 2016. *Nature Communications*.
<http://www.nature.com/articles/ncomms12227>
 doi:10.1038/ncomms12227



Le Croisic canyon, 835 metre deep in the Bay of Biscay



© Ifremer - Vicor 6000/Campagne BobEco



Carrying of sediments from glacial erosion by the Var, seventy kilometres from the river's mouth in the Mediterranean Sea

© CNRS/V. Rimeknecht

Glacial erosion dynamics over the past 50,000 years

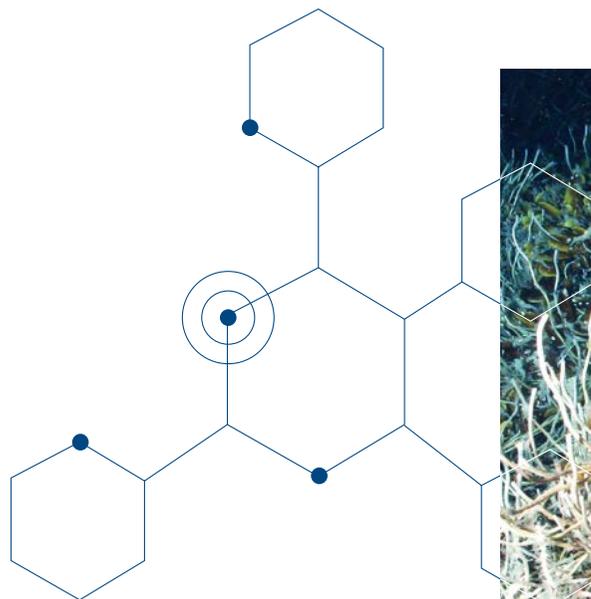
The ability of continental systems (catchments, glaciers, rivers, etc.) to transmit perturbations on the climate scale and erosion phenomena reaching sedimentary basins is a major question in studying land-sea sedimentary transfers. It is a complex issue for glacial periods, with the need to be extremely precise in limiting the stratigraphy of deposits sedimentary environments for which few records of the past activity of rivers exist on land. The high-resolution study of marine turbidity levees made this approach possible. It was addressed off the Var River, which is recognised as a system of reference. To this end, a combined sedimentology / geochemistry approach was performed on long core samples and examined the dynamics of land-sea transfers over the last 50,000 years. The results obtained demonstrated, for the first time in this way, that ocean basins can continuously record land-sea transfers over the millennial scale, and that rapid variations in climate have a direct effect on erosion from land and sediment transfers. Geochemical techniques highlighted the fact that a small percentage of the watershed, covered by glaciers until the beginning of the current interglacial, could in itself explain most of the dynamics observed and that sedimentary fluxes in the glacial period were 2.5 times greater than those observed today. More generally, this quantified results shows the importance of glacial erosion as compared to fluvial erosion and supplies a part of the answer to the debate focused on erosion-climate relationships (via CO₂ capture) over long time scales. Finally, a conceptual model of the reactivity of systems (depending on their size) was proposed, based on results obtained in the laboratory.

BONNEAU L. *et al.*, 2017. *Earth and Planetary Science Letters*. <http://dx.doi.org/10.1016/j.epsl.2016.11.004>

Marine litter of human origin in underwater canyons of the Bay of Biscay

The accumulation of waste and litter does not only affect beaches. All sorts of debris are also found on deep sea floors. During the oceanographic cruises BobGeo and BobEco, fifteen underwater canyons in the Bay of Biscay were explored by the remotely operated vehicle *Victor 6000* or the towed camera Scampi. Litter of human origin was systematically noted on the images taken by these two vehicles, showing that no canyon was free of litter and that this waste was found at every depth explored, between 200 and 2,000 m. The results in an article published in 2016 showed that plastics were very frequently found, making up 40% of litter; fishing nets and lines, cables and ropes, as well as glass bottles, also accounted for 40% of observations. The most likely sources of litter are fishing vessels, shipping or recreational boats, along with waste from land. This litter is regularly trapped in rocky areas of the canyons, as well as in reefs formed by species of cold-water corals. However, the impact of this litter is poorly known. While nets are responsible for ghost fishing, many bottles, wires and ropes provide support for sessile fauna. The greatest unknown factor comes from plastic litter and the long-term consequences of its degradation into microplastics which could be ingested by fauna and contaminate food webs.

VAN DEN BELD I.M.J. *et al.*, 2016. *Deep-Sea Research Part II*. <http://dx.doi.org/10.1016/j.dsr2.2016.04.013>



Gas hydrates observed at a depth of 3,800 metres

© Ifremer-Victor 6000/Campagne WACS

Processes of methane diffusion

Several recent studies have raised the question of a possible link between the decomposition of gas hydrates (gas molecules encased in cages of water molecules) - and methane hydrates in particular - and past climate change. To conduct this type of study, the first thing to do is to characterise the dynamics of gas hydrate systems during geological and natural sedimentary processes (gas circulation, sediment deformation, submarine landslides on the slope). This is usually done through a one-dimensional vertical analysis of sulfate-reduction coupled to anaerobic oxidation of methane within the sedimentary layers.

At Ifremer, a study on sulfate-reduction coupled to anaerobic oxidation of methane was addressed as a two-dimensional issue (horizontal and vertical directions) by considering the advection and diffusion processes which govern the transport of solutions (methane and sulfate). This was applied to a pockmark structure located at water depths of 1,100 metres in the deep Niger delta, where lateral methane advection through permeable turbidite layers was suspected. By analysing data acquired along several boreholes drilled during a research cruise, and after numerical modelling, the scientific team could show that only a two-dimensional approach can accurately describe the past dynamics of

such a complex natural system. Thus, the sulfate-methane transition zone should not be considered as a barrier for dissolved sulfate and methane circulation. Moreover, this modelling can also assess short time-scale variations in methane transport processes, which are essential to estimate the impact of global external changes on the stability of gas hydrates and associated sedimentary structures.

SULTAN N. *et al.*, 2016. *Scientific Reports*.
<http://www.nature.com/articles/srep26701>
 doi:10.1038/srep26701

INTERVIEW



Pierre-Yves LE GAC

ENGINEER AT THE BEHAVIOUR OF STRUCTURES
AT SEA LABORATORY

What are the advantages of using polymers in the marine environment?

Polymers, more commonly called plastics, are in widespread use in daily life owing to their numerous properties. In the marine environment, these materials do not undergo corrosion and they have interesting insulating properties in thermal and electrical terms. Their wide use is also explained by the lighter weight of structures: the densities of polymers are much lower than those of metals, for example. These materials are found in numerous marine applications like marine renewable energies, oil and gas production, submarines, etc.

What are the limits for their use?

The main limiting factor for use of polymers is their durability in the marine environment. Effectively, polymers age and weather under the effect of the environment (pressure, sea water), which leads to them losing their properties over time. Furthermore, in the marine environment, it is essential to have structures which are reliable over long periods (typically twenty years), due to the difficulties in carrying out maintenance. In the case of failure, the human, environmental and economic consequences can be both numerous and serious. To ensure the lastingness of objects and structures used at sea, it is indispensable to assess the long-term behaviour of polymers.

How do you assess polymers' durability?

The durability of polymer materials is one of the main research themes at the Behaviour of structures at sea laboratory. Polymers are subjected to accelerated weathering testing to reduce exposure times (from twenty years to a year or two). This is possible thanks to the special resources developed at the laboratory, such as hyperbaric weathering test chambers. The polymers are subjected to repeated mechanical stress and the mechanical fatigue-weathering coupling induced by the environment is quantified. The second phase is a question of understanding the type of degradation and more specifically the chemical reactions and physical phenomena at play, to be able to predict the loss of properties over time. Work to understand the mechanisms of weathering and prediction methods is done in the framework of research projects in partnership with large corporate groups (Total, EDF, DCNS) or SMEs, as well as via ANR or H2020 research projects.

What trends are foreseen in the years to come?

Materials and their marine applications are constantly progressing. The first development concerns using structures at increasingly great depths. This leads to increased pressure, which can modify the mechanisms of deterioration which come into play and thus the polymers' lifetime. The

second trend is mainly related to developing new applications like those for marine renewable energy sources. The final development concerns reducing the energy footprint of using polymers in the marine environment through optimally matching the effective lifetime of polymers and the service life of the structure they are utilised on. Developing new bio-sourced polymers (with plant fibres, for instance) falls within that framework. Our laboratory's knowledge related to the degradation of polymers is moreover a significant asset for understanding how microplastics form. This is a major subject for the years to come, particularly in the context of the Merlin Microplastics project.



© Ifremer/M. Gouillou

MARINE AND DIGITAL

INFRASTRUCTURES

Historically engaged in activities which are inherent to marine science research infrastructures like the French oceanographic fleet (TGIR FOF), it is natural that Ifremer support the strategy to structure and label research facilities and infrastructures pursued by the ministry in charge of research. Its organisation mainly relies on the engineering and technology teams who can summarise the needs expressed by scientific users, successfully carry out technological project to improve or upgrade the facilities making up the infrastructures and efficiently operate these infrastructures to the benefit of the scientific community.

The engineers and technicians assigned to research infrastructure activities are principally organised in “technological” units whose objectives and missions focus on infrastructures.

The French oceanographic fleet very large research infrastructure (TGIR FOF)

Following the year 2015 with the presence of RV *L'Atalante* in the Pacific, 2016 featured heightened activity for ocean-going vessels: *L'Atalante* was present in the Atlantic and the Mediterranean, while RV *Pourquoi pas?* made two incursions into the Indian Ocean.

2016 was also marked by the visit of the secretary of state in charge of higher education and research aboard RV *L'Atalante* in Brest, during which a new stage in the integration of the Fleet very large infrastructure was launched by presenting François JACQ with the official remit.

And finally, 2016 was a year when important steps in developing the HROV *Ariane* and new seismic equipment were accomplished and the modernisation of RV *Thalassa* was launched.

Modernisation of the oceanographic vessel *Thalassa*

The objective of this project is to broaden the range of *Thalassa's* mission beyond those of fisheries science and physical oceanography. To do so, the vessel will be fitted out with equipment enabling it to fully conduct its geoscience or environmental missions: bathymetric multibeam echosounders for shallow and deep water, sub-bottom profiler, coring equipment (minimum fifteen metres) and seismic equipment.

Funding of 16.1 million euros is sourced by three agreements: one with ANR and the other two with the Brittany regional council (ERDF and regional co-financing). Various calls for tender were launched, the biggest in June 2016 following a competitive negotiated procedure. The Piriou Naval Services company (Concarneau) was chosen to carry out the work.

Concurrently, optimisation of the fleet's scope was sought, based on thought and discussion conducted in 2014 about how Ifremer's activity should evolve within the European framework for data collection (DCF) on fisheries; thus, the CGFS European cruise to assess living marine resources in the English Channel is now performed aboard RV *Thalassa*. The decision was made to decommission *Gwen Drez* and she was dismantled in Brest in May 2016. Moreover, RV *Le Suroît* (forty-one years old) was put up for sale.

Renovating the seismic equipment

The aim of the renovation project is to upgrade and increase the capability of seismic equipment to provide the scientific community with two main sets of equipment based on the solid seismic streamer technology: SIS 1 (a 2D device with one 6,000-metre-long seismic streamer) and SIS 2 (a 3D device with two seismic streamers of 600 metres in length).

The project was launched in 2014 and is organised in five steps to progressively develop and fine-tune the new equipment. The finalisation of the first two phases of the project (perfecting the SIS 2 equipment with a 600-metre streamer and the SIS 1 equipment with a 4,500-metre streamer) marked the year 2015. The equipment was put into operation in 2015 and 2016 during the Ghass, Tecta, Pamela-Moz4, Pamela-Moz3-5, Antithesis and Caseis scientific cruises.

Development of SIS 2 continued in 2016, with trials to validate the 3D configuration in September. The last two phases of the project (upgrading the SIS 1 seismic source and lengthening the SIS 1 seismic streamer to 6,000 metres) began in 2016 and will be completed in 2017 with an integration phase and trials at sea.



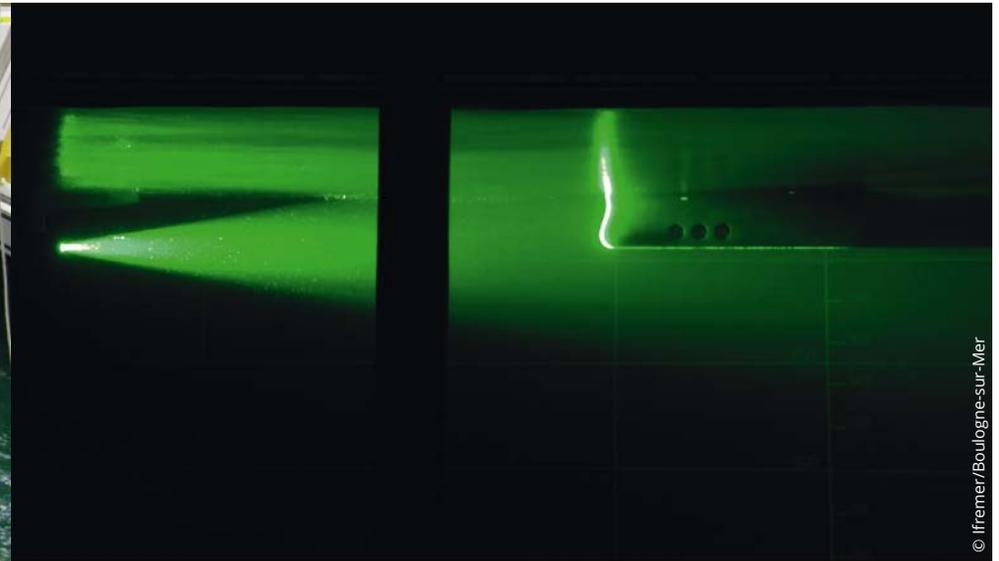
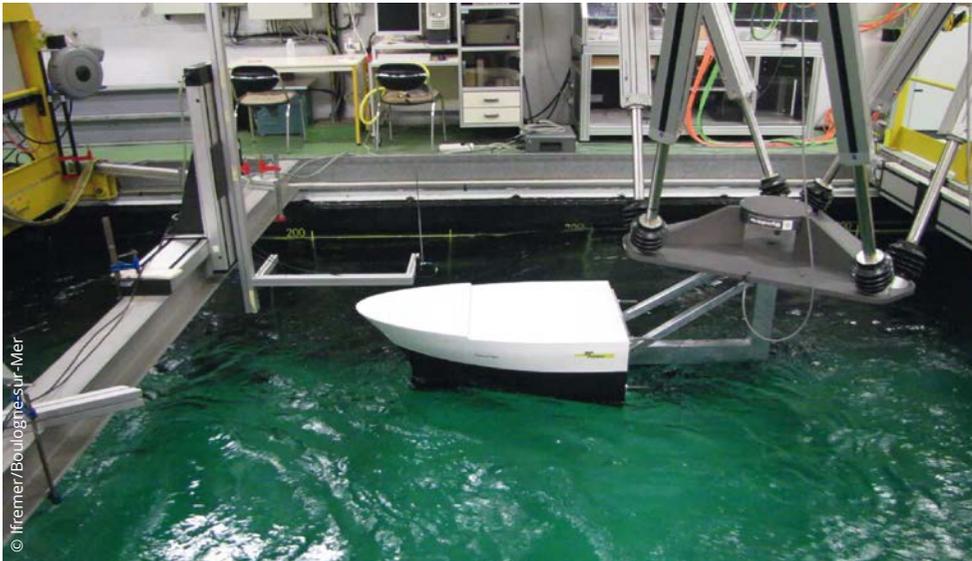
Deployment of SIS 2 seismic equipment aboard RV L'Atalante

Technical stopover for ROV Victor 6000

The ROV *Victor 6000* was given a three-month long technical stopover in 2016. Along with conventional maintenance, new power electronics were fitted into the vehicle's propulsion system. A new Otus2 vertical camera and

a new data and video recording system were installed. All these modifications were tested in the EssROV16 shakedown cruise which took place from the 1st to 15 August off Brest. After final tuning while in transit to the Azores, the *Victor 6000*

ROV was successfully deployed during the MoMarsat scientific mission on hydrothermal sites and the EMSO-Azores observatory.



Experimental system used to study the phenomenon of bubble sweep-down on a 1:30 scale model of RV Pourquoi pas?

Bubble sweep-down around the hull of research vessels

Developments are also focused on improving the sensors of vessels.

The objective of the *Bulles navires* (ships' bubbles) project is to study the phenomenon of bubbling around oceanographic vessels. It is crucial to obtain better knowledge about this phenomenon, because it leads to aeration in the environment and therefore to poorer performances of the acoustic equipment.

Initially, a fine-scale analysis was made of the conditions under which acoustic signal perturbation occurs, using databases from Ifremer vessels (*Pourquoi pas?* and *Thalassa*). The analysis determined the sea state and ship's movement conditions under which disturbances of acoustic measurements are noted.

Then a novel experimental device, reproducing the conditions under which bubble sweep-down appears, was developed to reproduce and characterise

the effects of interaction between the vessel and the waves. Physical modelling of the environmental aeration phenomenon in Ifremer's wave and current circulating tank, called upon the full range of the test facility's heavy equipment. The objective was to simulate the ship's speed (by generating a current), sea states (using a wave generator) and reproduction of the ship's movements (using the movement generator with six degrees of freedom and laser optics measurement systems and PIV (Particle Image Velocimeter) and LDV (Laser Doppler Velocimeter) systems. Trials were run systematically on different scale-model mock-ups (*Pourquoi pas?*, *Thalassa*, inverted bow, multi-mission vessel project). The results obtained characterised the dynamics of clouds of bubbles and suggest improvements in bow shape to limit the phenomenon's occurrence. An initial industrial application was carried out collaboratively with the Piriou shipyards. These studies were published in the *Ocean Engineering* journal.

DELACROIX S. et al., 2016. *Ocean Engineering*
<http://dx.doi.org/10.1016/j.oceaneng.2016.05.008>

Two examples of ocean research cruises

MoMarsat (Azores)

The MoMarsat cruise took place in September 2016 aboard RV *L'Atalante* in the Azores islands in Portugal's exclusive economic zone.

The expedition was jointly conducted by Ifremer and the IPGP earth physics institute in Paris, aiming to maintain the EMSO-Azores observatory in the Lucky Strike hydrothermal field. This sea floor observatory has been operated since 2010 and contributes to the acquisition of time series under ten years to understand the hydrothermal, tectonic and volcanic processes and the ecosystems of an active hydrothermal site on the Mid-Atlantic Ridge.

The system comprises an observatory infrastructure, strictly speaking, with a buoy (Borel) ensuring the transfer of data to a server on shore as well as communications with connected instruments, and two junction boxes (Seamon) on the seabed which communicate with the surface buoy using acoustics and which the instruments (OBS, video camera, colonisation modules, geochemical sensors) are connected to.

On the 2016 cruise, the observatory's measurement capabilities were increased by replacing the two stations' electronic core with a higher performance system (Costof2) and by incorporating new sensors (array of four hydrophones and geochemical sensors). The data transmitted via satellite are immediately available on an EMSO server (<http://www.emso-fr.org/EMSO-France>). The system

also includes autonomous instruments with internal data storage capacities. Measurements are taken *in situ* along with fluids and biological sampling to supplement the set of parameters and integrate a spatial component at each maintenance operation.

The seafloor observatory in the Azores area is one of the components of the European FixO3 (Fixed point Open Ocean Observatory network) programmes and EMSO, supported in France by the EMSO-France research infrastructure) which is steered through CNRS-Ifremer collaboration).

Several research institutes are an integral part of the project: IPGP and Ifremer which

conduct the MoMarsat missions, as well as the University of the Azores, the University of Lisbon, the University of Bremen and several French laboratories attached to CNRS (INSU and INEE): IUEM/UBO, OMP-GET, LOPS and UPMC/Locean.

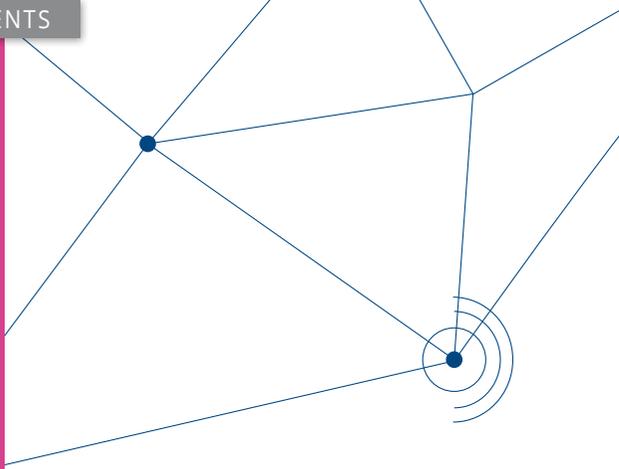
Caseis (Lesser Antilles)

The Caseis cruise conducted by IPGP aims to find the traces of major earthquakes on the Lesser Antilles arc (including that of 1843) and better determine the seismic cycle of the subduction zone through a submarine paleo-seismology study, based on turbidite/homogenite sedimentary records. With the support of Ifremer, whose teams developed

and deployed Cinema software for improved coring and managed the instrumentation developed in partnership with INSU and IPEV, the new corer aboard RV *Pourquoi pas?* was operated with a maximum weight of eight tonnes and length of 36 metres. It is equipped with a system that can release the set of pipes and thus allow the corer to be recovered if the uplift force is stronger than installation capabilities. Thirty-four coring operations were performed at depths ranging from 1,111 to 6,898 metres. The total length of cores sampled was 506 m. The recovery rate was quite good, seeing the nature of the cored sites, with a mean removal rate of about 75%.



EMSO-Azores observatory: using ROV Victor 6000 to install a chloride sensor in an active smoker at a depth of 1,700 metres



© G. Ruoppolo

Instrument connection on one of the EMSO Nice observatory's underwater stations

The EMSO Research Infrastructure (RI)

The legal formation of EMSO-ERIC (European Multidisciplinary Sea Observatory - European Research Infrastructure Consortium) which France is a founding member of, was promulgated on 29 September 2016. The actions taken to register the legal entity as company were successfully completed. CNRS and Ifremer are providing the French contribution and its governance within EMSO-France. The main observatories for Ifremer are EMSO-Azores and EMSO-Ligure with the EMSO-Nice cabled observatory on the airport's slope, the Dyfamed mooring and the SJB connection point on

the Antares site. A trial cabled observatory has been installed near Molène island in the "Iroise marine park" marine protected area.

In September 2016, EMSO-France (<http://www.emso-fr.org/EMSO-France>) commissioned the EMSO-Nice cabled observatory designed by Ifremer, set in a zone which is recognised to be a natural laboratory for studying submarine landslide phenomena. Research scientists now have live access to measurements and to settings of their instruments via internet. Thanks to this real-time connection, one of the instruments is part of the French seismology and geodesics network (Resif).

The year 2016 was also marked by the coming to maturity of the new electronic system for observatories (Costof2) for which a licensing contract was signed with the French firm RTSYS. It will be set up on the French observatories and disseminated over Europe in the EMSO framework. Thus, two Costof2 observatories have expanded the range of instruments deployed on the sea floor on the Lucky Strike site of the EMSO-Azores observatory by the MoMarsat expedition.

In the framework of the H2020 Emsodev project, which is funded by the European Commission to support ERIC EMSO, Ifremer developed the EMSO Generic Instrumen-

tation Module (EGIM). This key component will equip EMSO nodes across Europe, cabled observatories, autonomous observatories and moorings in order to supply harmonised measurements acquired using standard methods. EGIM is designed around Costof2. It has essential sensors for environmental monitoring: temperature, conductivity, pressure, dissolved oxygen, turbidity, and a Doppler current meter (ADCP) and hydrophone. The first EGIM module, delivered in September, is now deployed off Barcelona on the Spanish coastal observatory Obsea.



© J.M. Auxiette

Ifremer's RV Pourquoi pas? in Reykjavik

Tribute to Commandant Jean-Baptiste Charcot on the 80th anniversary of his death

RV *Pourquoi pas?*, owned by Ifremer and *Beautemps-Beaupré*, owned by the State (French Navy), are the result of cooperation between the Ministries of Defence and Research launched in 1999, with the objective of replacing three older vessels by two better adapted and more fully utilised vessels. The oceanographic vessel *Pourquoi pas?* took the name of commandant Charcot's last three-masted ship, which foundered off Iceland on 16 September 1936 during a scientific expedition. Since July 2006, and the first cruise performed for the French Navy hydrographic and oceanographic service SHOM (Mouton cruise), *RV Pourquoi pas?* has made numerous cruises on this partner's behalf. The Shoman 2016 cruise led the vessel to Iceland. During the call in Reykjavik, the Genavir crew and SHOM personnel took part in ceremonies held on the shipwreck site, followed by an official tribute with the President of Iceland and Commandant Charcot's granddaughter in attendance.

Regional council/CPER funding for labelled RI/TGIR

The State-Region plan contracts (CPER) drawn up for the period from 2015-2020 make significant contributions to the research infrastructures that Ifremer manages.

In this approach, the Brittany regional council helps support the following projects:

- The very large research infrastructure TGIR Euro-Argo, by financing the operational deployment of the new Provor Bio and Deep Arvor profiling floats, which are respectively able to measure new biogeochemical parameters and dive to depths reaching 4,000 metres. The CPER also co-finances the installations related to the ERIC Euro-Argo (European RI structure) being set up in Brest.
- The Ocean Odatis cluster, by financing the Datarmor project, an IT infrastructure for marine data storage/computation/processing. Odatis is one of the four components of the Earth system data clusters RI project.
- The ROEC project, which is part of the I-LICO RI grouping automated observation systems in coastal environments.
- The Ijinmor project, which consolidates the functions of the hydrodynamic test tank in Brest, and is part of the Theorem RI project frame.

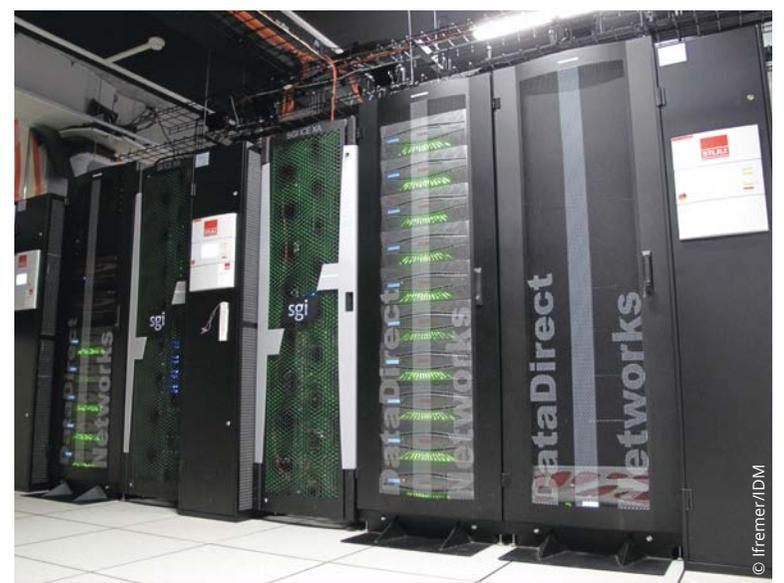
The *Hauts-de-France* region is funding the Marco project, whose aim is to implement a novel and innovative approach to study

the marine environment, its resources and the quality of seafood products in the framework of a regional drive taking environmental impact into account. Ifremer teams at the English Channel-North Sea centre specialised in fisheries science and the environment are involved in this project.

In the *Nouvelle Aquitaine* region, a CPER project is focused on Ifremer's station in La Tremblade and aims to rehabilitate its experimental facilities devoted to marine molluscs and particularly the experimental hatchery.

In *Provence-Alpes-Côte d'Azur*, the deep-sea AUV *Coral* project is co-funded by the CPER. It aims to consolidate the TGIR French oceanographic fleet's capabilities for deep-sea exploration and mapping.

As for the *Occitanie* region, it is financing the Celimer project, which Ifremer is taking part in through new installations devoted to sea and shore.



© Ifremer/IDM

The Datarmor digital computation and storage group to process marine big data

Marine data interoperability at national, European and international levels

Teams from many organisations conduct observations at sea, in the framework of various projects and funding. This diversity makes it possible to benefit from each team's expertise, whether on the theme, the region or the instruments. However, in this context, the data sets produced are often archived by several centres, which makes it extremely difficult to perform scientific analyses using collections of data: long time series, global coverage, co-located *in situ*

data - satellite data or the coupling of different themes (hydrodynamics/biology, for instance).

To overcome this difficulty, our Institute is leading several initiatives at present, promoting the harmonisation of marine data management and interoperability between centres, in France, in Europe and with our international partners:

- in France, the four data clusters for the Earth system and, in particular, the Ocean Odatis cluster coordinated by Ifremer. In the framework of these clusters, in technical terms, common procedures are currently being studied and implemented: catalogues listing and describing data sets and the context in which they were acquired, common vocabulary lists using a single way to identify the data handled, formats, the digital object identification (DOI) for each document, and so on.
- the H2020 project SeaDataCloud coordinated by Ifremer and designed to strengthen the SeaDataNet research infrastructure networking over one-hundred pan-European marine data centres. SeaDataCloud proposes to utilise large European Cloud Computing and Storage-type infrastructures in order to improve the accessibility and efficiency of the services made available (discovery, downloading, distributed access and visualisation) as well as their response time. so, SeaDataCloud can be considered, for *in situ* observations, as the European extension of the Odatis cluster. SeaDataCloud is one of the components in the European Earth observing infrastructures cluster Envri+;
- the ODIP2 project, which coordinates European, North American and Australian technical initiatives for marine data management. In this project, Ifremer has especially invested its efforts on descriptions (catalogues, vocabulary, formats, etc.) and exchanges of data acquired during ocean research cruises and on descriptions of autonomous observatories;

- the *in situ* component of the Copernicus marine environment monitoring service (Cmems), coordinated by Ifremer, which includes *in situ* products on the world ocean and European seas for physical or ecosystem forecasting and re-analysis requirements. These data are produced by over 7,500 platforms, coming from more than four-hundred data processing centres. These activities are carried out in cooperation with SeaDataCloud and EMODnet, in compliance with the standards defined at European and international levels;



- EMODnet, the European Marine Observation and Data Network, is an initiative of the European Commission's DG Mare, to promote inventories of marine data, prepare digital synthesis products and develop access to information for maritime stakeholders, in the framework of data harmonisation using intra- and interdisciplinary standards. Over a hundred European organisations are working in association to set up the dissemination of marine data which are interoperable and free of restrictions on use. Ifremer is involved in numerous themes: geology, bathymetry, physics, biogeochemistry and biology, and on more technical subjects like the data ingestion system.

This means establishing and adopting a common, standardised technical foundation, meeting the recommendations of European directives for environmental data management which can be implemented above and beyond the framework of these projects and memoranda of understanding with the Copernicus Marine Environment Monitoring Services, use of services by EMODnet, etc.



Traceability of geological and biological samples

Although the numerical data collected by Ifremer's oceanographic ships' instruments have long been databased for preservation, operations to collect samples, particularly geological or biological ones, was still too often recorded manually (log book) and each scientific team had its own way of doing it.

To provide uniform descriptions of the sampling operations and samples obtained, the SeaLog software developed by Ifremer is being progressively made available aboard research vessels in the very large research infrastructure called the French oceanographic fleet (TGIR FOF). This software makes it possible to note the sampling procedure (instrument used, geographical location and date) and describe what will become of the sample once it has left the vessel (where held, conditioning, labelling, etc.).

Aiming to guarantee the traceability of the samples taken, the descriptions are databased in the "cruise base" at the end of the expedition and the Archimède software program can be used to record information about their final destination, e.g. a core repository, a rock repository, the Deep ecosystem study unit's collections, the MNHN national natural history museum, etc. This software is used onshore and facilitates pursuing work in the laboratory or in sample repositories. It was developed in the framework of Carnot funding and offers the following functions: entering and updating metadata (dives, sampling and/or measurement operations, samples), rock repository management (storage address, movements, sub-sampling), visualisation and queries for operations and samples, import/export of metadata to geographic information systems.



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Retrieval of multitube corer, recovering sediment samples aboard RV Pourquoi pas?

Setting up a bioinformatics platform

The lower cost of high-throughput sequencing has opened the possibility of using genomic exploration in many cases of biological studies focusing on fields ranging from the metabolism of cells and organisms, to biodiversity, phylogeny and the functioning of ecosystems. Indeed, numerous teams at Ifremer now implement new genomic sequencing technologies on a regular, or even a daily, basis. The Merlin projects, and first and foremost that for the Abyss, have also heightened this need.

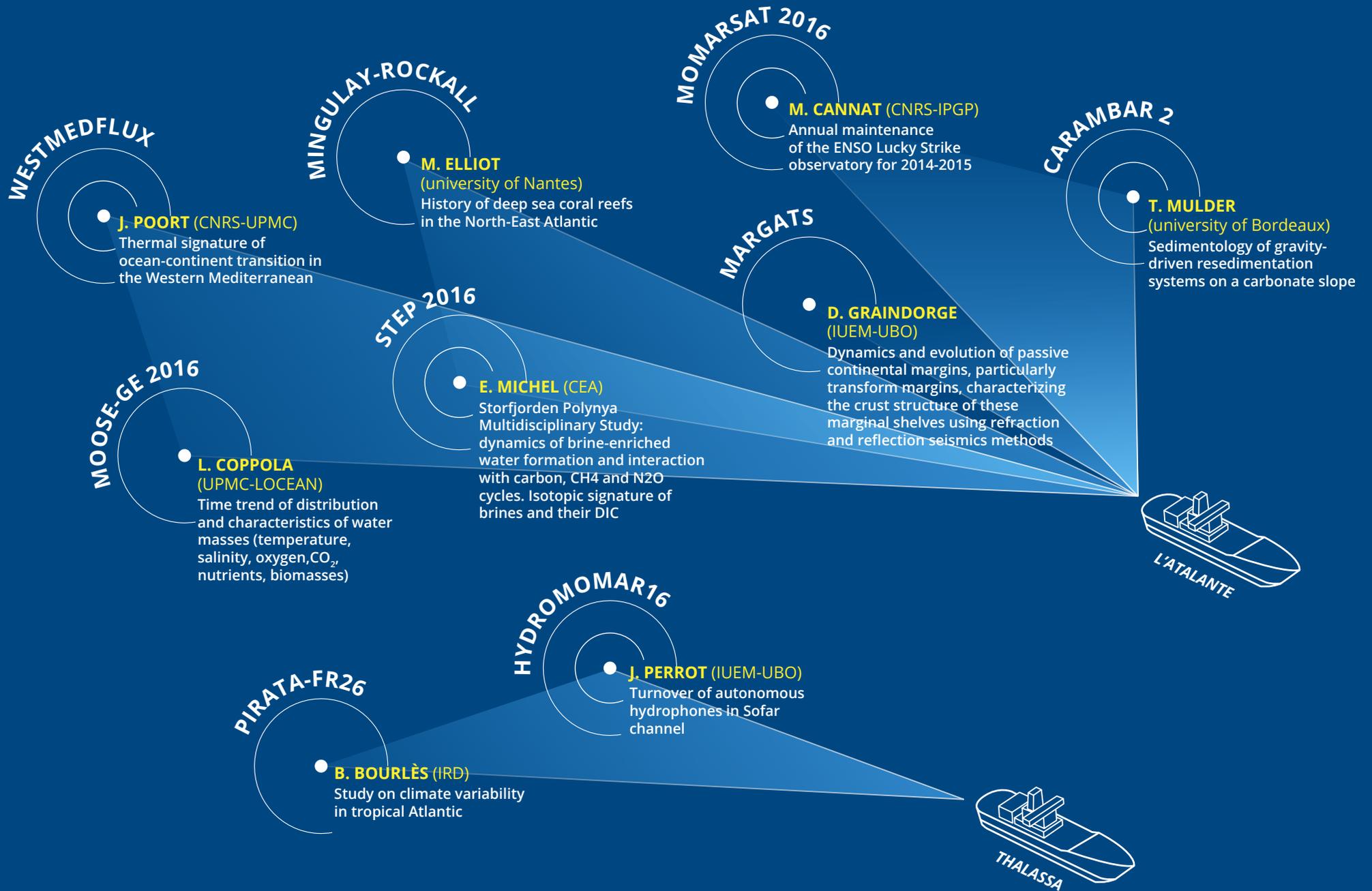
Ifremer is part of this worldwide trend, where the number of available sequences is doubled every two years. This requires significant IT resources: drives to store the large volumes of data produced, software tools and the related processing capabilities. The software tools for sequence analysis are also varied: searches and annotations of proteins by translating known sequences, looking for sequence homology in a database starting with another sequence (Blast), aligning sequences to track their

genetic evolution, finding patterns (tags) to characterise them, genome assemblies, statistical and phylogenetic processing.

To be able to propose this tool palette and facilitate its deployment by scientific teams, Ifremer has set up a bioinformatics platform responsible for implementing the tools, maintaining them in operational condition and providing technical support for their use. With two permanent staff engineers currently running the platform and regularly hosting apprentices on sandwich courses, this unit enables the pooling of proposed services. At present, these services rely on the Caparnmor computational infrastructure. They will be sponsored by Datarmor in 2017, to offer notably increased storage capacity and processing capabilities.

The bioinformatics unit also works in coordination with similar initiatives in other institutions (e.g. the Abims platform in Roscoff) to share knowledge and optimise tool deployment and training costs.

OCEAN-GOING FLEET - NATIONAL COMMISSION



317
DAYS

ANTITHESIS 3

B. MARCAILLOU
 (university of the French West Indies and Guiana /Guyane)
 Seismogenesis and tectonic deformation of the Antilles margin: thermicity, structure and fluid pressure in the deep margin, consequences on location of seismogenic zones, links to partitionning of the deformation

CASEIS

N. FEUILLET
 (IPGB)

DRADEM

C. BASILE
 (university of Grenoble)

ROVSMOOTH

M. CANNAT
 (CNRS-IPGP)
 Architecture of the lithosphere in slow-spreading ridges and continent-ocean transitions, Indian Ocean



OCEAN-GOING FLEET - OFFSHORE CRUISES OF PUBLIC INTEREST

141
DAYS

IBTS 2016

Y. VÉRIN (Ifremer)
 Ecosystem-based approach to fisheries resource assessment

PELGAS 2016

M. DORAY (Ifremer)
 Monitoring populations of exploited small pelagics

LEVÉ-SMF

E. PELLETER (Ifremer)
 Survey on sulphide permit zone



CGFS 2016

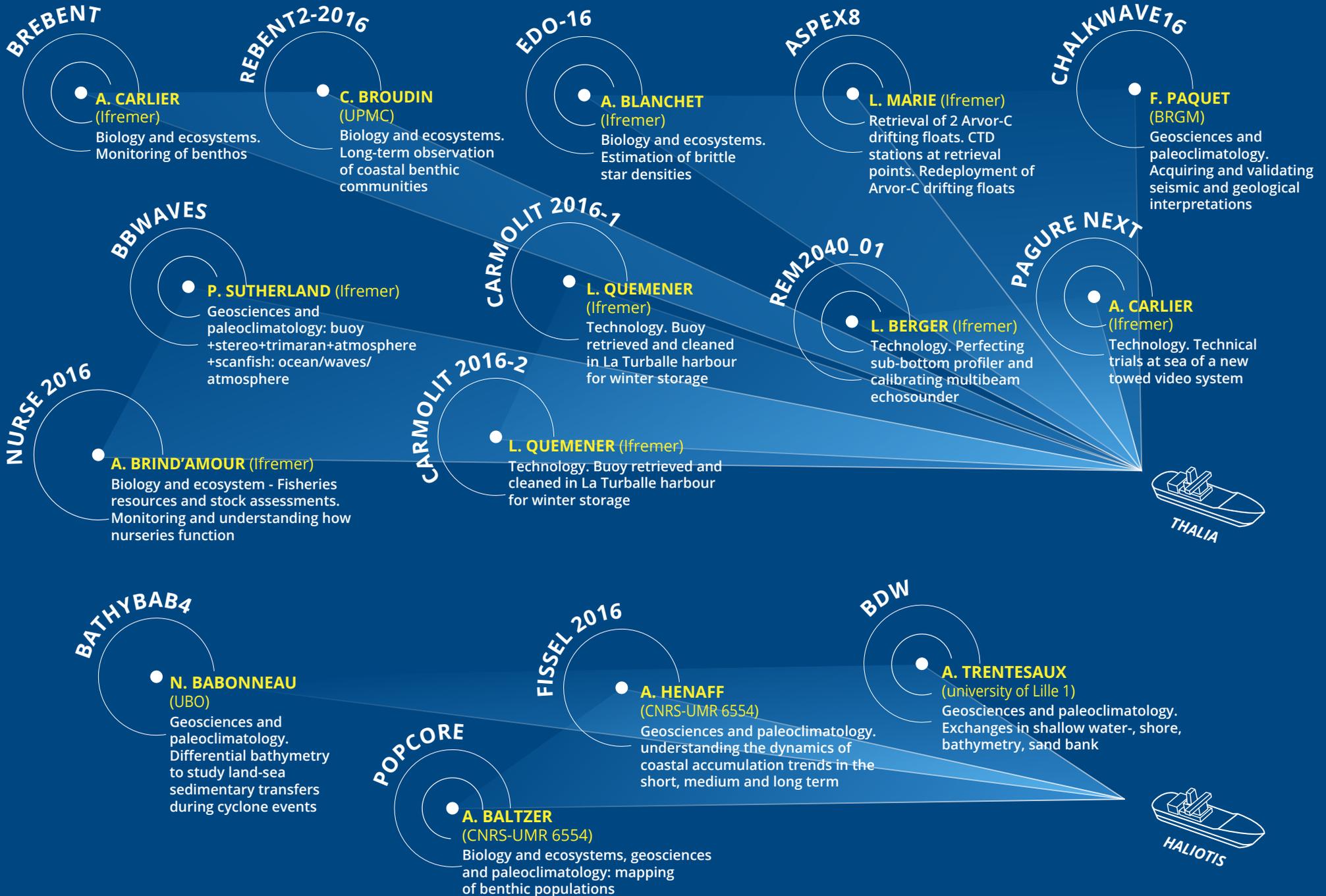
M. TRAVERS-TROLET (Ifremer)
 The CGFS cruise objectives are to collect basic data to estimate the state of resources for direct assessment of stock abundance and distribution, combined with biological sampling of catches

EVHOE 2016

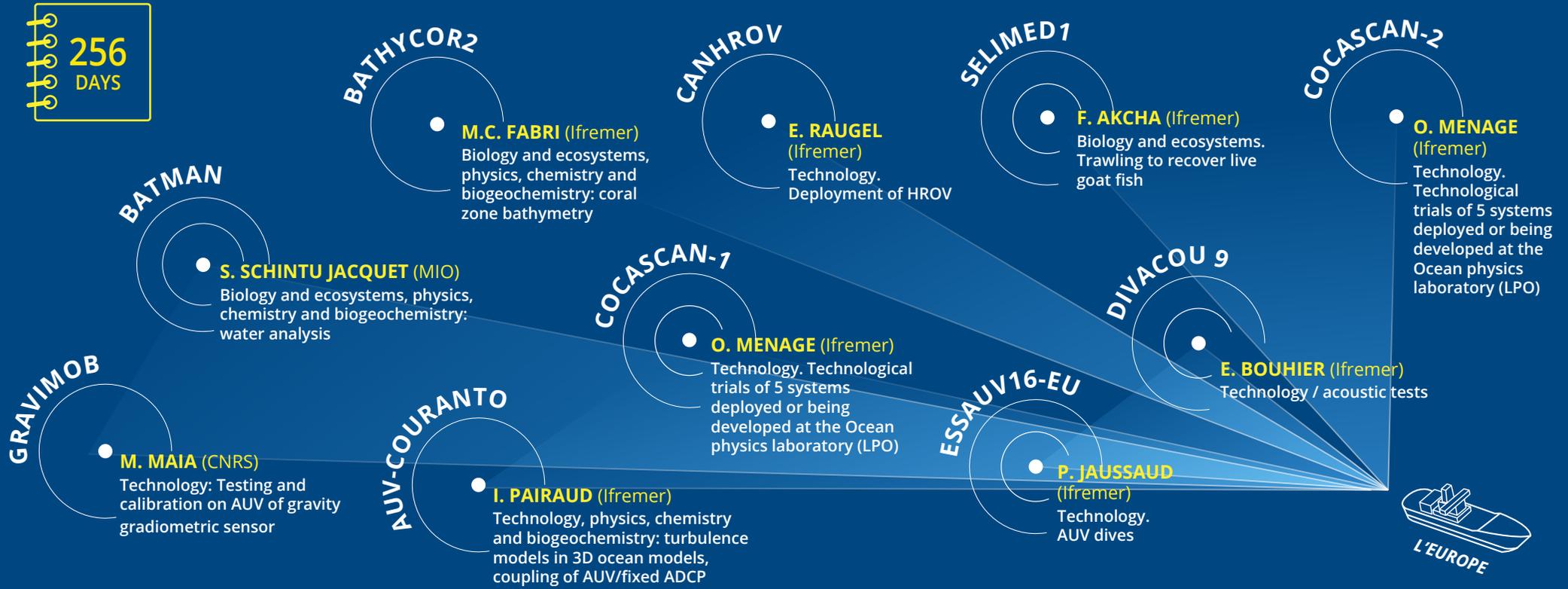
J.-P. LÉAUTÉ (Ifremer)
 Fisheries resource assessment. Impact of fisheries on populations. Observatory of living resources



COASTAL FLEET - NATIONAL COMMISSION

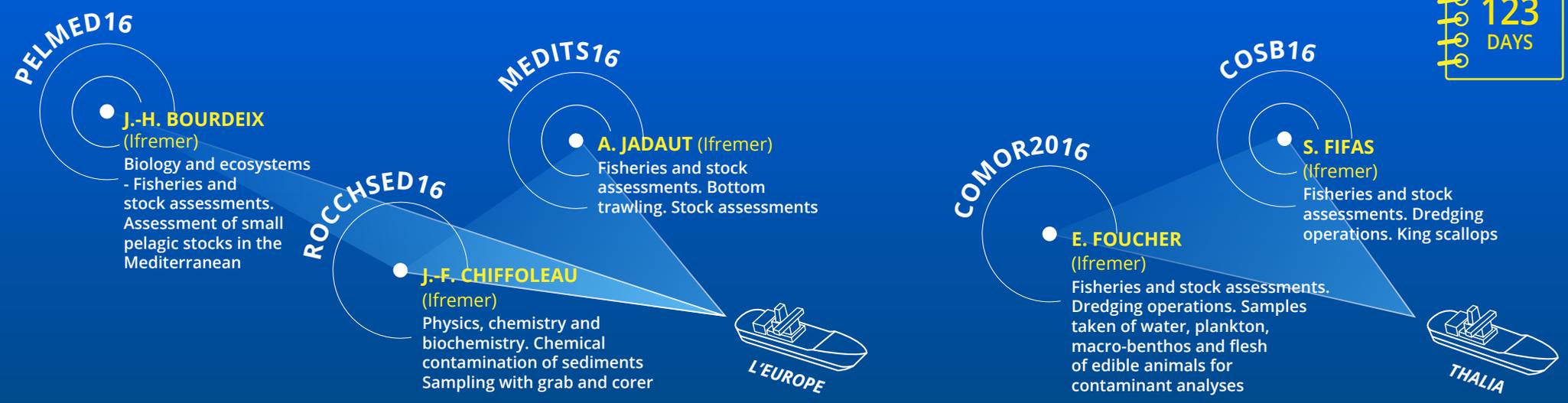


256
DAYS



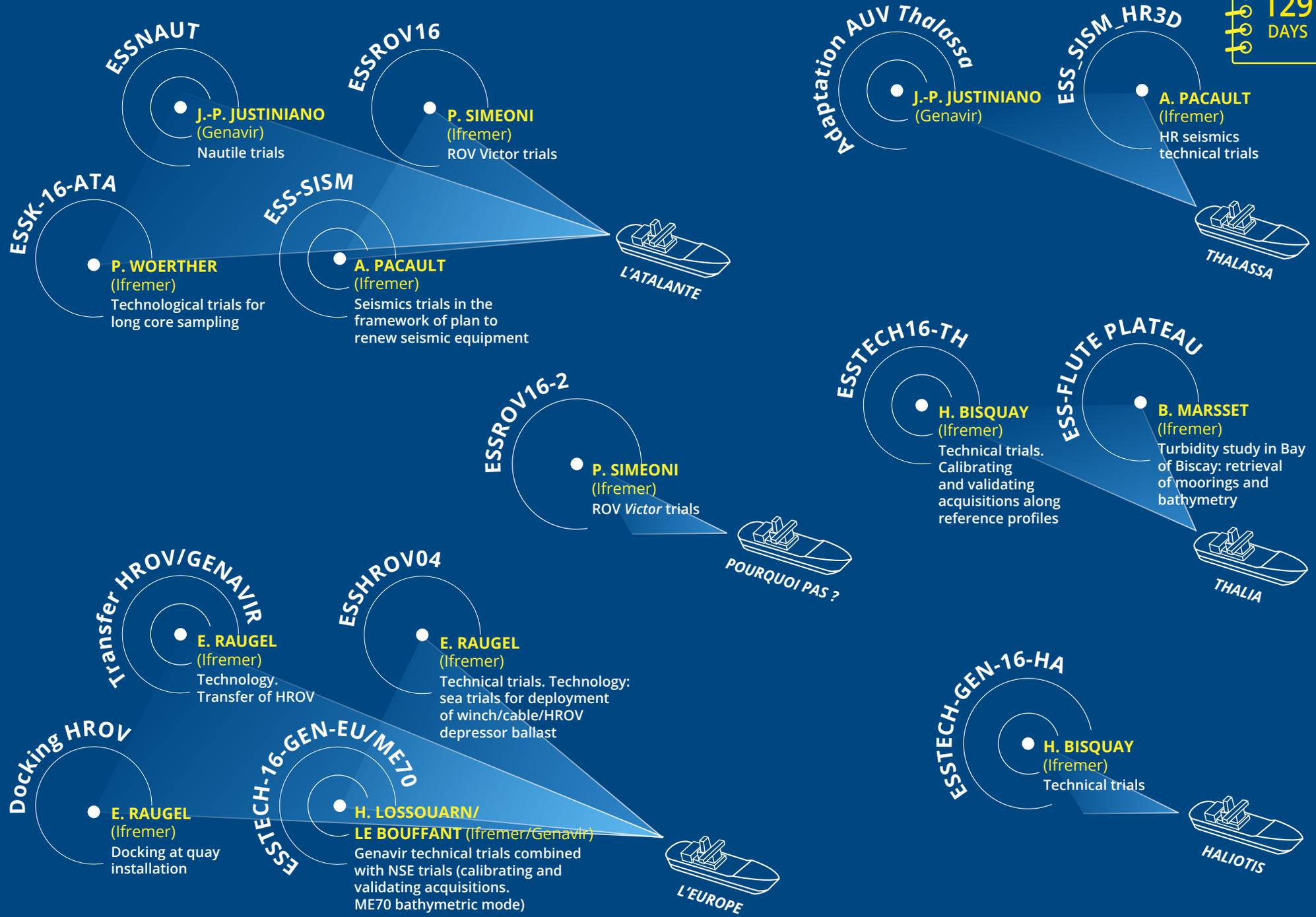
COASTAL FLEET - INSHORE CRUISES OF PUBLIC INTEREST

123
DAYS



TECHNICAL TRIALS MISSIONS

129 DAYS



FRENCH NAVY-IFREMER PARTNERSHIP

SHOMAN

● **SHOM**
Hydrography cruise for the French Navy's hydrographic and oceanographic service (SHOM)



POURQUOI PAS ?

SHOMANTILLES

● **SHOM**
Hydrography cruise for the French Navy's hydrographic and oceanographic service (SHOM)

SHOMDYN

● **SHOM**
Hydrography cruise for the French Navy's hydrographic and oceanographic service (SHOM)



L'ATALANTE

122
DAYS

COOPERATION BETWEEN RESEARCH AND INDUSTRY

VOLT1-RECUP-TH

● **R. SILVA JACINTO** (Ifremer)
Turbidity study in Bay of Biscay: retrieval of moorings and bathymetry



THALIA

VOLT1-RECUP

● **R. SILVA JACINTO** (Ifremer)
Turbidity study in Bay of Biscay: retrieval of moorings



THALASSA

VOLT2

● **R. SILVA JACINTO** (Ifremer)
Turbidity study in Bay of Biscay: deployment of moorings

PAMELA-MOZ03

● **M. MOULIN/ D. ASLANIAN** (Ifremer)
PAMELA project



POURQUOI PAS ?

79
DAYS

SCIENTIFIC CRUISES ASSESSED BY OTHER COMMISSIONS THAN CNFH AND CNFC

GRACO

● **M. GARCIA** (CSIC - university of Grenada)
Eurofleets



L'ATALANTE

10
DAYS

CHARTERS

RETZ1

● **L. GEOFFROY** (IUEM-UBO)
Charter



HALIOTIS

AFF

● **BGR**
Charter



POURQUOI PAS ?

ESSNAUT-SUB

● (SUBMERGENCE)
Charter



L'ATALANTE

38
DAYS



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EUROPEAN AND INTERNATIONAL PARTNERSHIPS

In 2016, the United Nations Organization solicited numerous stakeholders, including the Intergovernmental Oceanographic Commission (IOC) in which Ifremer takes part as an active member of the French committee, to draw up the post-2015 development agenda based on sustainable development objectives. Under objective 14, the oceans are acknowledged to be an integral part of sustainable development. The important role that they play was also emphasized during the IPCC's 43rd session in Nairobi (Kenya) in April 2016, where it was agreed to prepare a special scientific report on climate change and the ocean. During the G7 summit meetings of the seven major economic powers which took place in Tsukuba (Japan) in May 2016, the Science and Technology Ministers and the European Commissioner in charge

of Research, Science and Innovation, identified the “future of the oceans and seas” as a critical issue for economic development and highlighted the importance of developing scientific knowledge to assess the changes underway and their impact on economies, whilst promoting the implementation of policies aiming to ensure the sustainable use of seas and oceans. Ifremer participated in all these actions both with the IOC and through its involvement in the Ocean and Climate platform or its role in the French delegation for AllEnvî within the Oceans JPI. Moreover, Ifremer continued its engagement in European construction and pursued strategic cooperation on the international scene.

Strategic cooperation with Asia

The twenty-sixth joint session of the French-Japanese Ocean Development Sub-Committee was held on 2 and 3 June 2016 at the Ifremer headquarters. For several years now, Ifremer has been entrusted with its coordination by the Ministry of foreign affairs, and the Japanese coordination is ensured by the Ministry of education and research (MEXT). This joint subcommittee brings together all the projects and institutions collaborating in the marine science field, i.e. twenty-six projects dealing with ocean observation (the research field deemed high priority at the last G7 meeting), deep-sea ecosystems and marine technologies. The projects were structured by theme, highlighting the two countries' contribution through this collaborative work to research policy-making and international cooperation.

The EcoDeep project on deep-sea biological systems represents tangible progress in the cooperation between Jamstec (the Japan Agency for Marine-Earth Science and Technology) and Ifremer, particularly for future possibilities of exchanging ship time between the two institutes. An Ifremer research scientist who is the coordinator of EcoDeep took part in a cruise conducted by Jamstec in the Pacific through this project. This marks a step in cooperation, especially for developing protocols to study the environmental impact of future mining activities, particularly on sulphides from hydrothermal vent sites.

Ifremer has also cooperated with South Korea since the early 1990s. Our historic partners there are NFRDI (National Fisheries Research and Development Institute) and Kordi which is now the Kiost. New projects are underway with the universities of Kunsan and Jeju.

A delegation from Ifremer, with the support of the scientific cooperation team at the French embassy in Korea, went to South Korea from

23 to 27 May 2016 under the official aegis of France-Korea Year. The visit was set up around the signing of a memorandum of understanding between Kimst (Korea Institute of Marine Science and Technology Promotion) and Ifremer on 24 May 2016, followed by a Kiost-Ifremer working group meeting on subsea technologies.

Kimst is a national agency affiliated to the Korean Ministry of Oceans and Fisheries in charge of the strategic programming of marine and maritime research and the allocation of related funding.

Finally, in 2016, new contacts were made with China: Ifremer was invited by the Qingdao national laboratory for marine science and technology to the Global Ocean Summit; an international laboratory was launched, associating the third Chinese institute in the State administration for the sea and the joint research consortium UMR LM2E (Extreme environment microbiology laboratory, Ifremer-CNRS-UBO).



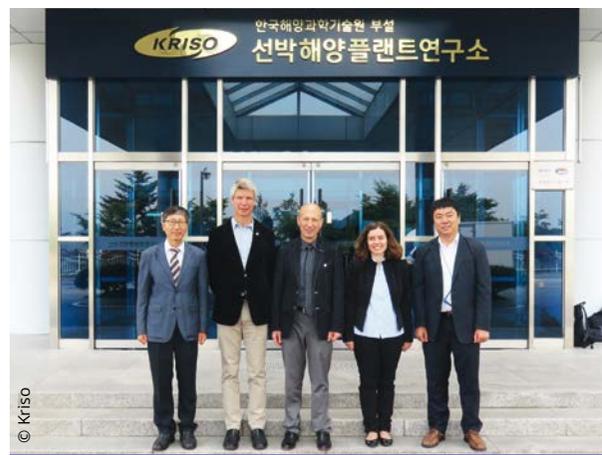
The marine science and technology group (European Marine Board) in Sopot (Poland) in April 2016

Highly promising outcomes of European calls for proposals

Between 2014 and 2016, Ifremer's success rate in H2020 programme calls for projects was 28%, higher than both the national success rate (14%) and the European success rate (10%). For average annualized income in 2016, Ifremer showed a rise of 14% (mean annualized H2020 income for the period from 2014-2016, i.e. €4.9M compared to 4.3 million euros for the period from 2007-2013).

The European projects which Ifremer contributes to fit into the French national research strategy published in 2015 by the ministry in charge of research.

To make its strategic objectives part of the European research area approach, Ifremer is present in numerous European networks. Our Institute also participates actively in the International Council for the Exploration of the Sea (ICES) and is an active member of organisations like Efarø (the European Fisheries and Aquaculture Research Organisation) associating the directors of institutes in these fields and SCAR Fish (the Standing Committee in Agricultural Research), the Research subgroup which our Institute will chair in 2017, as well as EurOcean (the European centre for information on marine Science and technology) for which Ifremer held a vice-presidency in 2016. Furthermore, the institute contributes to the analyses made by the European Marine Board, being one of its vice-Chairs and provides its expertise to the European Consortium for Ocean Research Drilling (Ecord) by chairing the Facility Board since the 1st of January 2016. Ifremer is also a member of Clora (the French club of associated research organisations).



The Ifremer delegation with their South Korean counterparts, in May 2016, at the Korea Research Institute of Ships and Ocean Engineering (Kriso)

SINCE 2014, IFREMER HAS BEEN INVOLVED IN

H2020 PROJECTS INCLUDING

3 AS COORDINATOR

AND HAS SUBMITTED **104 H2020 PROJECT PROPOSALS**

Ifremer, a stakeholder in the Galway Statement

The Galway Statement was signed in 2013, an initiative between the European Union, the United States and Canada, with the objective of developing a culture of scientific cooperation on the Atlantic Ocean.

The H2020 project Aorac-SA (<http://www.atlanticresource.org>), which Ifremer takes part in and which is facilitating this cooperation, has been the catalyst since 2015 for various actions such as:

- optimising Trans-Atlantic legs aboard French (*L'Atalante* from Ifremer), Irish (*Celtic Explorer* from the Marine Institute) and Canadian (*Louis S. St-Laurent* of the Department of Fisheries and Oceans, Canada) vessels for Trans-Atlantic seabed mapping surveys;
- interactions between marine research platform operators and scientists;
- supporting Trans-Atlantic working groups on seabed mapping, aquaculture;
- a network set up between European projects for the Atlantic (Atlas, AtlantOS, Sponges, Vivaldi) and other international initiatives (e.g. the Ocean Frontier Initiative in Canada, the US-Ocean Observatories Initiative).



IRSO-Aorac-SA meeting (October 2016, Italy)



C5th Trans-Atlantic seabed mapping survey aboard Canadian Coast Guard Ship Louis S. St-Laurent performed between Halifax and Tromsø (from 22 July to 2 August 2016)

International cooperation in the Mediterranean

To support the implementation of the Blue-med initiative for blue growth in the Mediterranean, the European Commission decided to fund a consortium led by the CNR (*Consiglio Nazionale delle Ricerche*, Italy) under an H2020 coordination and support action (CSA). Ifremer and CNRS are amongst the eleven partners of the project, representing eight countries (Italy, Spain, Greece, Croatia, Malta, Slovenia, Portugal and France). The objectives of this four-year project which began in 2016 are to consolidate Bluemed's strategic agenda for research and innovation, lay the foundations of long-term coordination of its activities and draw up an implementation plan, ensuring that countries from the southern shores of the Mediterranean are associated.

The Mediterranean is a unique area for research in terms of its marine biodiversity and interactions between human activities and the environment. Its ecosystems are subjected to rapid modifications caused by global change. At the same time, the Mediterranean's characteristics hold significant potential for developing sustainable ecosystem services ranging from fisheries to tourism. Bluemed aims to better integrate knowledge and efforts to promote blue growth in the Mediterranean basin for the creation of new "blue jobs", promote social cohesion and improve environmental status and social well-being there.

2016 was also the year of the forty-first congress of the Mediterranean science commission (CIESM) held in Kiel. On this occasion, a broad overview of research in the Mediterranean was presented. Ifremer represented France at the CIESM board meeting there.

Ifremer is a member of the regional Mongoos (Mediterranean Oceanography Network for Global Ocean Observing System) alliance whose objective is to promote operational oceanography, coordinate the services proposed in the Mediterranean region and foster related research and development. In this framework, Ifremer is charged with facilitating the modelling working group. In partnership with the IOF (Institute of Oceanography and Fisheries, Croatia) in November 2016 in Split, Ifremer organised a scientific workshop on Mediterranean advanced modelling, especially progress made on recurrent meteorological tsunamis in the Balearic Islands or in the Adriatic Sea, which could also occur on other coasts.

On 2 May 2016, a delegation from the national institute of fisheries research INRH (Morocco), led by its general director Abdelmalek Faraj, came to Ifremer's headquarters. This visit established the basis for renewing the framework agreement between our two institutes. Discussions were also held about cooperation for fisheries and coastal environmental information systems, with the perspective adapting tools developed at Ifremer in this field to INRH's needs.



INTERVIEW

Asahiko TAIRA is a geologist by training, professor emeritus at the University of Tokyo and the President of Jamstec. In 2016, the American Geophysical Union created the Asahiko Taira International Scientific Ocean Drilling Research Prize in his honour.

How would you describe the cooperation between Jamstec and Ifremer?

The collaboration between our two institutes goes back over thirty years and made it possible to carry out one of the most successful integrated projects in submarine sciences, the Kaiko project. Effectively, this project enabled the investigation of deep trenches in Japan in 1985. In fact, it was on one of the expeditions that your submersible Nautile dived to a depth of 6,000 metres for the first time!

Since then, we have collaborated in the fields of marine geology, geophysics, oceanography and engineering. More recently, we have turned our attention to marine biology, assessment of ecosystems and the marine environment. We share a system to exchange scientists and take part in symposia and joint working groups, which enable us to promote our cooperation. For instance, an Ifremer researcher made a fruitful stay at Jamstec and we progressed in our environmental approach to assessing mining exploitation. These collaborative studies are often part of a regional and international framework of cooperation, particularly in international networks of scientists engaged in inventorying marine life (Census of Marine Life) and in studying the history of

the earth and sea floor dynamics (International Ocean Discovery Program, IODP).

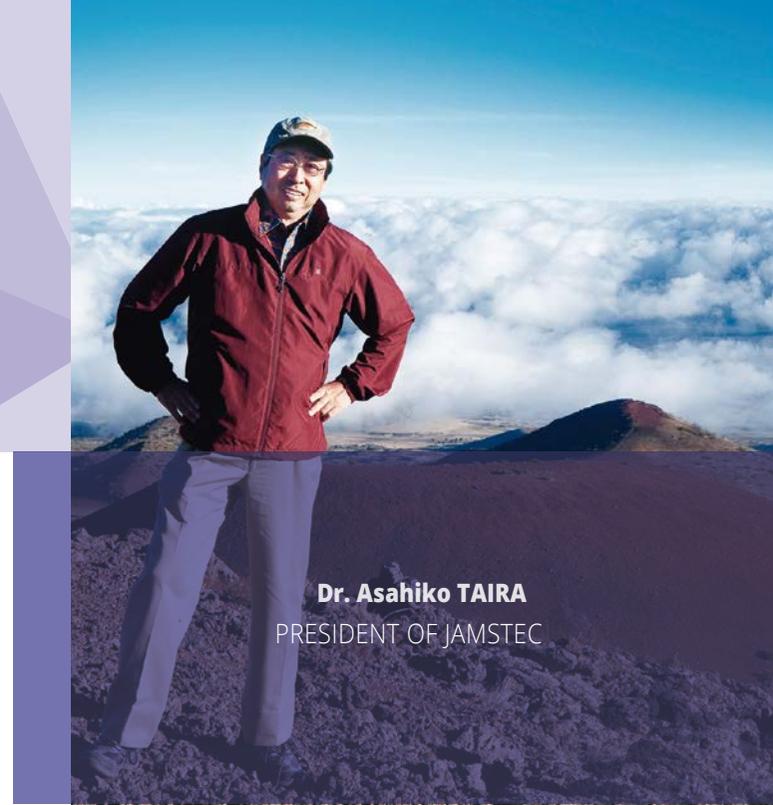
What can this collaboration bring with respect to possible developments in the Asia-Pacific region?

The Asia-Pacific region, and especially the South Pacific area features a vast ocean frontier comprising many chains of islands and small continents. The region is very complex in environmental terms, unknown in many aspects and strategic on the global level. Japan and France are great maritime nations, so it is natural that we should collaborate in order to understand the scientific and socio-economic aspects of the ocean and terrestrial zones in this region. This research must include marine resources, marine biodiversity, natural hazards and sustainable development of societies in this area of the world.

We need long-term planning of integrated approaches and to increase our efforts so that this bilateral collaboration becomes the core of regional and global collaboration to understand the role the Asia-Pacific region plays in sustainable global development.

What is the future for marine research in Asia and the Pacific?

I think we need to focus on long-term project, but integrated ones. Since the region is complex, a broad and integrated approach is essential for the development of marine research.



Dr. Asahiko TAIRA
PRESIDENT OF JAMSTEC

It must include geosciences, biological, physical and environmental sciences and social sciences, as well as an inventory of technologies. However, the research must be targeted.

No country or organisation can develop such programmes alone. International cooperation and networking are vital for their success. In my opinion, promoting and setting up a network which would be at the centre of many other networks is the surest way for this approach. Rapidly launching this research should comprise objectives such as preventing risks from marine geohazards (earthquakes, tsunamis, hurricanes, etc.), balanced development of marine resources and using underwater geological space to capture and store carbon and other waste management.



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SUPPORT FOR PUBLIC POLICY-MAKING

Scientific studies conducted by Ifremer provide support for deploying maritime policies, whether the implementation of the Water Framework Directive (WFD), the Maritime Strategy Framework Directive (MSFD), policies for human and animal health, the Common Fisheries Policy (CFP), or those for aquaculture or national strategies for biodiversity, energy or mineral resources.

Work to support public policies represents about one third of Ifremer's activities. It is done in part within our research units and relies on the Institute's locations along French seafronts for the observation and monitoring of the environment and resources. These establishments implement the monitoring/ observation systems which are coordinated on the national level and through their expertise, contribute to policy decision making by decentralised State services.



Marine fisheries: a changing regulatory framework

The CFP reform aims to control fleet capacity to avoid situations of overcapacity and resulting overfishing of marine resources. It seeks to progressively phase in the landing obligation for all catches, increase regionalisation of management measures, grow the participation of stakeholders and combating illegal, unreported and unregulated fishing (IUU) and create a single European Maritime and Fisheries Fund (EMFF). A CFP priority is to bring back and maintain levels of fisheries stock exploitation to a maximum sustainable yield.

Effectively, Ifremer is regularly solicited to assist the Maritime fisheries and aquaculture division (DPMA) in European and international negotiations on total allowable catches (TAC), by using the ecosystem-based models which supply the most comprehensive assessment of fisheries resources.

Ifremer's strong involvement in the field of fisheries policy is founded on a full fisheries science information system, going from collection data to managing them a dedicated database and making them available. This system forms the basis of the French contribution to the European DCF programme, and, specifically for Ifremer, takes the form of contributing nearly two hundred ocean research cruise days.

In 2016, the national study programme for the period from 2017-2019 was drawn up, thus creating a framework for acquiring knowledge related to the Common Fisheries Policy, actively involving Ifremer and our experts.

One ambition of the new CFP is also to make it coherent with the “environmental pillar” of the European Union’s integrated maritime policy through the Marine Strategy Framework Directive (MSFD). Indeed, sustainability of fisheries can only be addressed through an ecosystem-based approach which takes account of the uses which influence biological resources of different scales, global change and the various pressures exerted on the marine environment. Ifremer is involved in both fields of investigation, and carried out a year-long study to link the needs and demands under the CFP with the requirements of the MSFD.

Redistributional effects of fishing quota management systems

In France, fishing quotas are shared among producer organisations (PO) based on historical landings by their members. Each PO is responsible for implementing their own internal rules that provide individual or collective allocations to their members. In an article published in the *Fisheries Research* journal in 2016, Ifremer examined the distributional effects of various quota management systems adopted by POs on quotas and production for the Bay of Biscay sole fishery.

Results show that the French management system, based on POs’ pooling and redistributing quotas, successfully avoided the concentration of production while reducing fishing capacity through decommissioning schemes.

The fact that fishing allocations cannot be transferred and the State’s delegation of management powers to POs are elements that favoured this outcome, by allowing POs to control the distribution of catch shares in the fishery.

BELLANGER M. *et al.*, 2016. *Fisheries Research*. <http://www.sciencedirect.com/science/article/pii/S0165783616300972>

MSFD: developments in the definition of good environmental status

The Marine Strategy Framework Directive requires that European Union’s Member States take necessary measures to reduce the impacts of human activities on the marine environment in order to achieve or maintain Good Environmental Status by 2020 at the latest. The Institute, jointly with the Agency for marine protected areas (AAMP), acts as scientific and technical coordinator, supporting the Ministry in charge of the environment for the various strands of the directive.

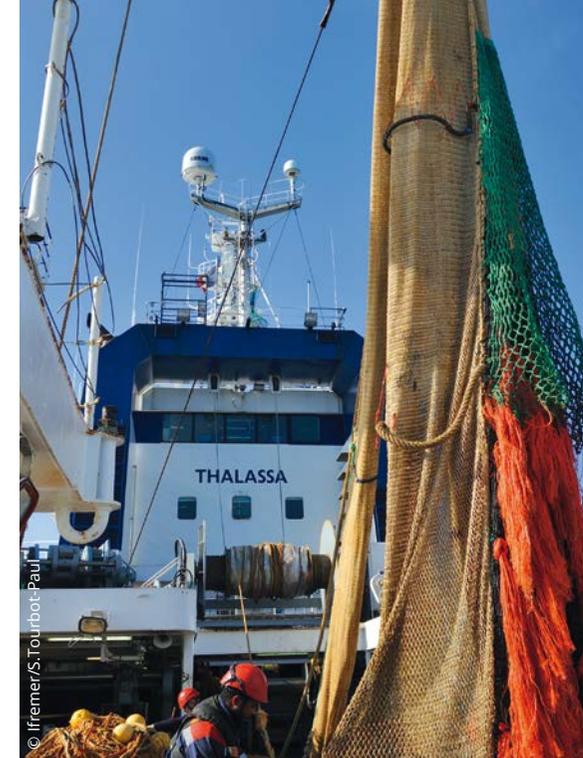
The definition of GES was adopted in a 2010 decision which can be revised every six years. Over the year 2016, the eighteen MSFD scientific pilots belonging to the French scientific community (Anses, BRGM, Cedre, CNRS, MNHN, SHOM, universities and Ifremer), examined the different versions of the GES draft decision and appendices under revision. The final version of these texts was adopted by the Member States at the Regulatory Committee meeting on 10 November 2016.

The new decision strengthens the MSFD’s links with the relevant European regulations already in effect (WFD, directives Habitats

and Birds Directives, CFP). Member States are invited to cooperate with neighbouring countries to identify lists of species and habitats to be assessed and to establish threshold values. This can be based on the studies developed in the framework of regional sea conventions (Ospar and Barcelona Conventions for France).

The new Decision is based on eleven descriptors, as before, but they are broken down into forty-two criteria as opposed to twenty-nine in the 2010 version. There were initially fifty-five indicators, but that concept has been eliminated for greater simplification. Twenty-four of the forty-two criteria are designated as primary criteria. They must be informed by each Member state to ensure coherency across the European Union. The others are identified as secondary criteria. The concept of primary and secondary criteria gives each Member State more flexibility in assessing GES.

In 2017, in France will review the initial assessment of good environmental status of marine waters, published in 2012. This revision will be based on the new definition of Good Environmental Status. The work has involved mobilising additional resources at Ifremer, the linchpin of the operation.



Trawling operation aboard RV Thalassa

Ensure greater safety for shellfish consumers

Ifremer is engaged in a multiannual study to develop methods to detect microalgae toxins which are not yet amongst the toxins monitored in the framework of regulatory surveillance of the health quality of shellfish. The programme will also make it possible to highlight non-regulated emerging toxins in France and determine how dangerous they are for consumers. The study is led by the General directorate for food and associates the Bio-toxins national reference laboratory at Anses.



BUSINESS DEVELOPMENT AND ECONOMIC PARTNERSHIPS

Above and beyond our objectives of producing knowledge and meeting social demands, Ifremer contributes to economic development by creating economic value from its studies, as well as transferring them to the socio-economic sector. Effectively, it is our Institute's ambition to share the benefits of "blue growth" with French and European companies, corporate groups and SMEs and support sustainable growth in the marine and maritime sectors. With that perspective in mind, Ifremer's action is based on:

- turning know-how into value, as well as setting up partnership-based research projects enabling economic stakeholders to benefit from scientific achievements so that they can propose innovative products and services in utilising the ocean responsibly;
- our Institute's positioning in the prime fields of interest for "blue growth" (energy, bio-sourced products, the environment, mineral resources, etc.);
- technological developments implemented to answer the major scientific questions that Ifremer is ready to tackle, by producing innovative tools which can be taken to sufficiently high levels of technological readiness (TRL);
- Ifremer's research infrastructures, very often taken to the European level, and whose calling is to serve the national economic development.

Framework agreements

Salsa

Salsa (Sergipe Alagoas Seismic Acquisition) is the outcome of working in collaboration between the Petrobras oil group and Ifremer. Established as of 2009, it focuses on our Institute's expertise and experience in geophysics and geodynamics. The project follows on from the Sanba (2010-2013) and Magic (2012-2015) projects. Twelve multi-channel and wide-angle seismic profiles and their extensions on land have been processed and interpreted, in complement to drawing up the catalogue of passive margin typologies. Positioned on a broad segment of the Brazilian margin, going from Jequitinhonha to Sergipe (Nordeste, Brazil), to either side of the Camamu triple junction, the resulting data have shed light on the dynamics of the continental crust thinning process, the role played by tectonic legacy and the geodynamic phases governing the movements of continents.

Moreover, the results challenge the models usually employed, especially in terms of thermal evolution, tectonic movements and sedimentary recordings, which are essential for quantifying how organic matter has evolved over geological time scales.

Passive Margin Exploratory Laboratories – Pamela project

Continental margins make up the transition zone between continents and deep sea floors. So-called active margins are the site of intense tensions, because they are areas where two tectonic plates collide. Passive margins, as they are called, separate two continental plates where an ocean is created and are, in principal, calmer.

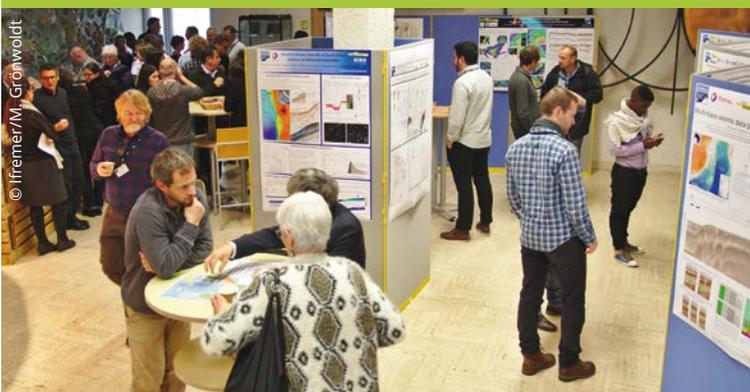
The Pamela project is investigating some passive margins with complex activity, particularly:

- magmatism and volcanism at depths and at the surface;
- vertical movements of geological layers and sea level positions over various periods of time (from a few dozen to millions of years);
- erosion/deposit cycles, from continental catchment basin to sea bed accumulations and the impact that climate variations have on continental or carbonate sedimentary systems;
- the origin and role of fluids migrating from deep layers up to the surface;
- the impact of currents on seafloor sediments and deep-sea ecosystems.

These phenomena are being studied on several study sites, such as those in the Bay of Biscay, east of Corsica and mainly in the Mozambique Channel. In 2016, Pamela-Moz3 and Pamela-Moz5, two seismic exploration cruises focused on the deep structure of the Mozambique Channel margin and specifically on the continent-ocean transition.

The project is jointly conducted by Total and Ifremer, also associating the universities of Paris VI, Rennes I and UBO, CNRS and Ifpen. The partnership is managed in a consortium framework, making it possible to perform specific actions like research cruises and their related studies and PhD theses or post-doc studies on innovative subjects. Engineers and scientists alike, with a range of skills and expertise are involved in the project.

Pamela 2016 seminar at Ifremer's Brittany centre



Collaborative work

Vasco 2

The applied research programme Vasco 2 aims to make biological use of carbon dioxide (CO₂) by cultivating marine microalgae to produce biofuels. Ifremer is one of the main partners in this project gathering numerous stakeholders: industrial firms (ArcelorMittal, Kem One, Solamat Merex, LyondellBasell), the Aix-Marseille-Provence metropolitan council, start-ups (Coldep and Helio Pur Technologies), research bodies (CEA and Ifremer) and a consultancy firm (Inovertis).

The experimental phase launched in 2015 reached a milestone in 2016, with the installing of cultivation ponds on the Fos-sur-Mer industrial site.

Seychelles Fishing Authority

Ifremer is renewing its support for the Seychelles Fishing Authority (SFA) by setting up statistical processing procedures for their fisheries information system in 2016 and 2017. In the long run, this will enable the SFA to have estimations of fishing efforts and catches per species, per métier and per fleet, for instance, all supplied routinely.

Service provision for the Major seaport of Guadeloupe

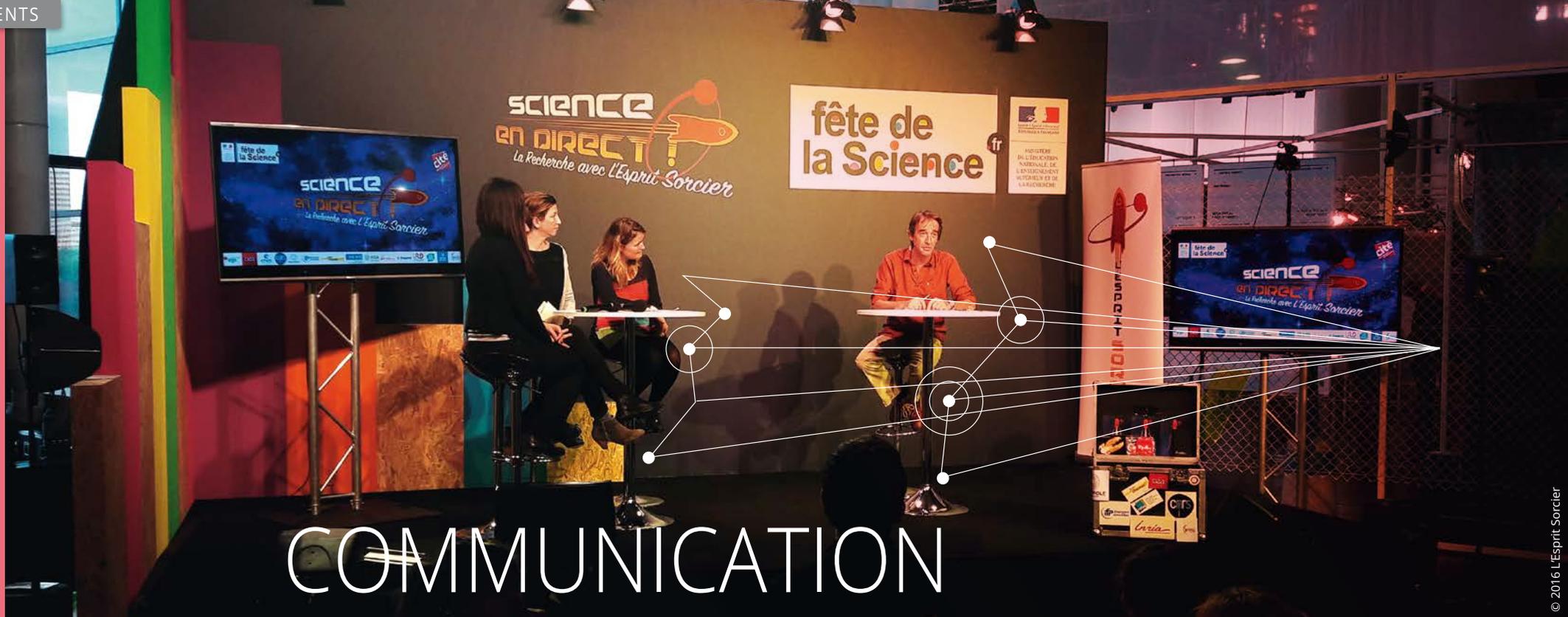
In the framework of work on the big project for the Major seaport of Guadeloupe, Ifremer was instructed to implement fisheries monitoring in order to assess the impacts of the work on professional fisheries activity. The Institute relies on its expertise to fulfil two parts of this remit:

- assisting the contracting authority to analyse and interpret the results of experimental fisheries cruises, which themselves were made by the Fisheries and mariculture committee of Guadeloupe, following a predetermined protocol in consultation with Ifremer;
- characterising trends in fishing activity (efforts and yields) in the zones which could be concerned by the work on the seaport.



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Developing the Grand Port maritime de Guadeloupe seaport (Pointe-à-Pitre)



COMMUNICATION

Following on from its remit for research and expert assessments, Ifremer participates in disseminating scientific and technical knowledge. For many years now, our institute has proposed a cycle of lectures at the Ifremer Centre in Brittany to share the advances made in marine science research with the public. Once again, this year, the public lectures webcast on the Institute's Web TV have been very popular with Internet users. Moreover, Ifremer has an exceptional image bank of still photos and films which can be used to highlight the Institute's activities through partnerships with stakeholders in scientific and technical culture. In 2016, Ifremer worked in association with Vulcania, which created a new, permanent attraction called *Abyss Explorer* simulating a dive into the ocean's depths. Ifremer also loaned images and supplied scientific expertise for two exhibitions: one of them organised by the Zoological museum of Strasbourg on the theme of *Light! Exploring the impossible*, and the by the Botanical garden of Bordeaux on the theme of *Star WAtERS: the galaxy of plankton*. As it does each year, Ifremer actively participated in the science festival in the regions of France and in Paris where fifteen research institutes joined with *L'Esprit Sorcier* entity popularizing science and discovery and the *Cité des Sciences et de l'Industrie* to create the Live Science event supported by the Ministry of national education, high education and research.

Reinforced in-house communications

To help the Institute function more efficiently, several actions were also undertaken to develop communications within Ifremer. An electronic internal newsletter was established to this end; it is sent by email to all employees, usually once a month. One of the columns, called *Cape Ifremer*, is devoted to life and work at the Institute and can meet employees' need for information about subjects that are structuring for the institution. To complement the arrangement, a one-day meeting with the general management was set up in each Ifremer centre in metropolitan France. Salaried employees could ask their questions either prior to the day via an on-line form or during the round table discussion organised in the morning. In the afternoon, facilitated events were organised to help discover several activities carried out at the centre, to encourage discussion and exchanges between employees.

Ifremer strongly mobilised during the seventh Maritime festival event in Brest

Brest's maritime festivals began in 1992 and are held every four years in a week-long event. Truly a "world's fair of the sea", this year from 13 to 19 July, it attracted over 700,000 visitors. An event which showcases the heritage of traditional boats and ships from every region in the world, it also provides the occasion to raise people's awareness about the maritime region of Brittany which innovates in the field of marine sciences and technologies. The *Quai des Sciences* section, organised by *Océanopolis* and the Atlantic Brittany maritime cluster (PMBA), found its audience with 21,000 visitors. Located in the merchant harbour, where ships' chains used to be stored, in an area of 2,500 m² made up of several pavilions, it brought together all the local academic and industrial stakeholders. Over three hundred speakers took turns over the six days to raise the general public's awareness about the maritime realm and what is at stake for it.

Research vessel *Thalassa*, docked near three- and four-masted Tall ships, took 4,000 visitors on board during the 6 days of festivities. The presence of RV *Thalassa* at the maritime festival also provided the opportunity to present the vessel's upgrade project slated for 2017 to financial and other partners. Two actions were also undertaken to enable people with disabilities to fully enjoy the maritime festival.

Quai des Sciences workshops during the Brest 2016 maritime festival



Women in marine sciences

For International Women's Day on 8 March 2016, our Institute created a series of nine video portraits of female scientists. They work as marine ecology researcher, bioinformatics scientist, marine data manager, shipboard electronic engineer, chemical lab technician, and so on... bringing drive and passion to their marine science-oriented jobs. In short videos lasting two or three minutes, these women present what they do and how they came to do it, and encourage other women who hesitate to start scientific studies and careers. Ifremer has enacted a proactive policy in terms of gender balance.



882,144
VISITS TO
INSTITUTIONAL
WEBSITE



4,204
FACEBOOK
SUBSCRIBERS



7,942
TWITTER
FOLLOWERS

Redesigning the web sites

Ifremer's web site was redesigned in May 2016, overhauling both the tool itself (EzPublish) and the corporate design, now offering visitors a more user-friendly access to information, particularly thanks to the redesigned graphics, changing to a display which adapts to the size of screen used and a sophisticated browsing system. For the ifremer.fr institutional site, these changes are also accompanied by a complete editorial overhaul with content fully reviewed and revised. The website's layout was entirely redesigned, and several new headings created, such as those of Economic development and Public policy support.

Marine-related books at Editions QuAE

Ifremer is one of the four founding bodies, along with Cirad, INRA and Irstea, of the Quae publishing house, now an acknowledged player in scientific and technical publication in France. This selection of books in French published in 2016 illustrates the marine environment's wide range of facets: *Histoire de la pêche à la ligne* (History of angling); *Les étoiles de mer et leurs cousins* (Sea stars and their cousins); *La Loire fluviale et estuarienne* (Loire - river and estuary); *La pêche à pied, histoire et technique* (History and techniques of recreational shore fishing); *Mémento de planctologie marine* (Marine planktonology guide).

City of sciences and the sea at the America's Cup in Toulon!

The French stage of the preliminary circuit for one of the major sailing races worldwide, the America's Cup, was held from 9 to 11 September, in Toulon. The event provided the opportunity for the Toulon Provence Mediterranean (TPM) metropolitan area to organise a City of sciences and the sea, to showcase the research bodies, academia and industrial firms all working to develop the scientific and technological reach of the Var region's maritime territory. As coordinator of the "Research" pavilion, in a 60 m² space, Ifremer presented a gallery of underwater vehicles which have marked its history, from *Archimède* to the HROV *Ariane*, as well as the manned submersible *Nautile*. A dozen mock-ups helped visitors understand the technological breakthroughs associated with each vehicle and discover the most spectacular scientific breakthroughs which attracted the most media attention. Visitors could also learn about the human adventures which accompanied the design and use of these vehicles during research cruises aboard oceanographic vessels.





ACCOMPANYING AND SUPPORTING RESEARCH

In 2016, Ifremer pursued its action for greater efficiency and consistency in practices within the Institute, as well as its quality management system. These developments require especially attentive management of human resources. The tools to manage and monitor budgetary aspects have been upgraded, and this contributes to our Institute's efforts for good management.

Transfer of headquarters to the Brest-Plouzané site

A specific agreement for staff mobility was signed to meet three objectives: find a solution for each employee concerned, provide financial and personal support and ensure Ifremer's good operation. A mobility agreement was signed by the unions in the summer of 2016, with the purpose of supervising the arrangements for internal and external mobility.

The agreement provides for support measures covering the various types of situation, so that each employee receives a proposal adapted to their case. Thus, the agreement offers a wide range of approaches: support for job seeking, training, financial aids for mobility and special measures to support the oldest employees.

Professional and social development

Training, a tool to support Ifremer's strategy

Acknowledged by one and all as a vital element in developing the skill sets of its employees, Ifremer's training policy played an essential role in implementing the Institute's strategy, and particularly in 2016.

The year was marked by the implementation of a special training plan aiming to support the deployment of the new SAP financial and accountancy management software and by the move to the new budgetary and accounting standard (GBCP public-sector budget and accounts management). The additional funding allocated to these training actions represented about double the budget usually devoted to ongoing training and further education.

This means that 176 people were trained for the presentation of the new GBCP standard, for a total of 2,370 hours of training.

Likewise, an unprecedented effort of 9,042 hours of training courses adapted to different types of users made it possible to prepare teams for the deployment of the new SAP management tool.

Along with these forms of action, Ifremer remains true to its fundamental commitments to host young men and women preparing for their future careers.

Thus, the Institute has further grown its training capabilities for employees on sandwich courses and as of the end of 2016, had fifty-three apprenticeship and vocational contracts underway, preparing at levels ranging from BTS higher technical certificate to Master's or Engineering degrees.

Also, the French civic service agency has renewed its confidence in Ifremer, for a new five-year period: by late 2016, twenty-six volunteers were hired in our locations in overseas France.

Finally, in the workforce at the end of the year, the Institute had eight-four PhD students and twenty-one post-doc fellows. Mention should also be made of the co-financing provided by the Institute for grants for PhD students working in our partner organisations.

Social protection

Mindful of Ifremer employees' social situation, the unions at the Institute have supplemented the Health coverage by a group benefit plan.

Closing two research stations at L'Houmeau and La Trinité-sur-mer

After conducting processes to consult the staff representative bodies, in July 2016 Ifremer confirmed that two stations would be closed, by the end of 2018 at the latest, with the aim of streamlining its territorial network. Work was launched in September for the reassignment of the employees in question.

Voting modalities in professional elections

In keeping with its will to refocus Human resources on their role as a partner working closely with the operational teams, at the end of the year, Ifremer signed a company agreement with the unions ratifying the setting up of an electronic voting system for staff representative elections (only applicable to employees in metropolitan France for legal reasons).

Promotion of in-house skills

Ifremer is also pursuing its efforts to promote acquired skill sets and develop career prospects: the twenty-eight training courses leading to diplomas or qualifications (most of them in the framework of accreditation of prior experiential learning), ten PhD theses in further education programmes and thirty-nine accreditations to supervise research (HDR), underway in late 2016, make a major contribution.

Disability awareness campaign

Ifremer conducted a campaign to raise awareness amongst its employees about disabilities, during the European disability employment week which ran from 14 to 19 November 2016. The objectives of the campaign were to explain to the broadest possible audience the different types of disability which may be encountered and to highlight the stakes and challenges of making workers with disabilities part of enterprises. By broadcasting a video on a different theme each day, the campaign reached a large number of viewers in a fun and educational approach.

The Institute's workforce

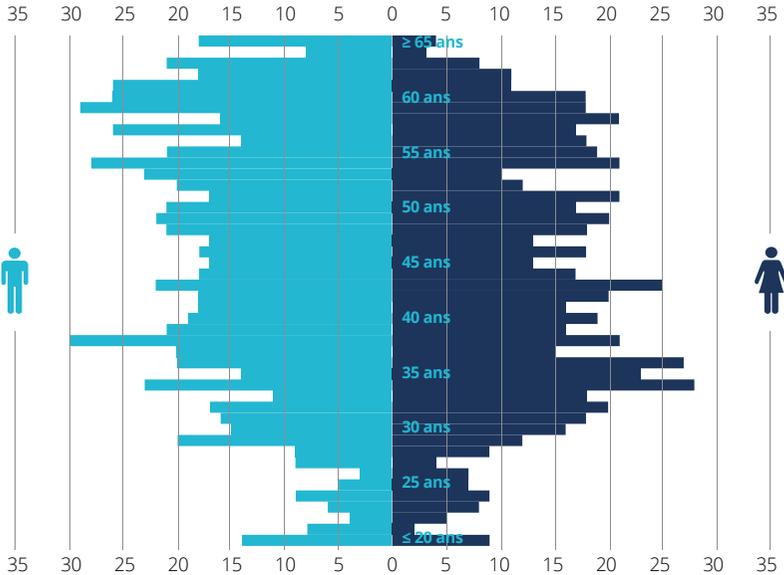
Ifremer's total workforce as of 31 December 2016 was 1,478 salaried employees, including 172 on fixed-term contracts.

The breakdown between managerial and technical staff is 60% managers and 40% technicians.

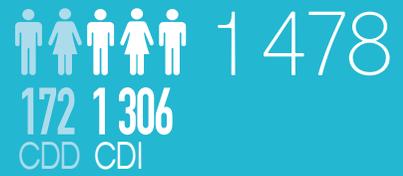
78% of new hires hold managerial positions and most them are women.

Furthermore, the proportion of female employees is continuing to grow: they represent 46% of the Institute's total workforce. This development can be explained by the sharp rise in the proportion of women recruited (58% of sixty-nine hires, i.e. + 12 points from the previous year).

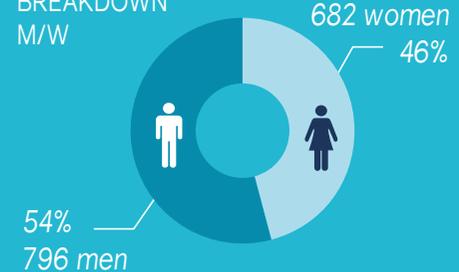
AGE PYRAMID AS OF 31 DECEMBER 2016



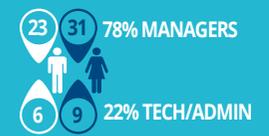
WORKFORCE



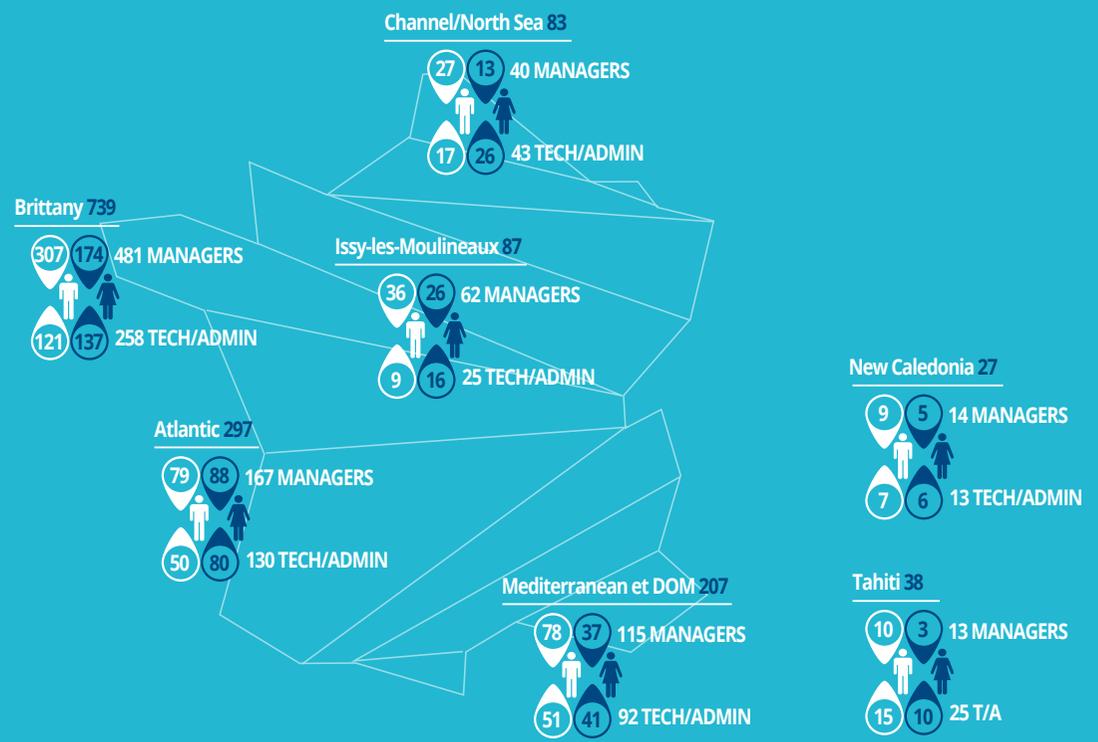
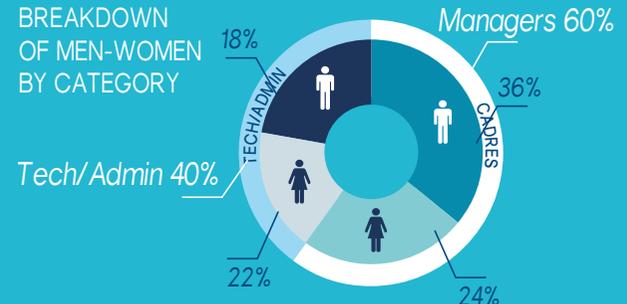
BREAKDOWN M/W



69 RECRUITS



BREAKDOWN OF MEN-WOMEN BY CATEGORY



Ethics and the professional code

In 2016, Ifremer decided to formally endorse the principles of the national charter for professional ethics in the field of research signed on 26 January 2015 by CPU, INRA, Inserm, CNRS, Cirad, Inria, IRD and the Curie Institute. It has conducted its own application, taking effect on the 1st of January 2017, making the keystone of its system for professional ethics and scientific integrity.

To ensure the implementation and the operational application of this system, a position was created for an ethics and integrity representative who will report to Ifremer's chairmanship.

Transitioning the quality management system to the ISO 9001:2015 standard



Ifremer's quality management system (QMS) meets the requirements of ISO 9001 in its 2008 version, which enabled it to be certified by AFAQ-Afnor in November 2012 and to keep its certification since then. In April 2016, the Institute decided to launch the plan to transition to the new version of the standard (called ISO 9001:2015) with the obligation to present a QMS which is appropriate for the certification audit of November 2017.

Three objectives are being pursued in this transition plan:

- to simplify the existing system based on the experience acquired over the past five years and the possibilities offered by the new standard;
- to identify the risks and opportunities which could affect the course of our Institute's activities;
- and to strengthen the involvement of management staff and those steering the process.

Sustainable development and corporate social responsibility

In 2016, Ifremer took part in the assessment of the corporate social responsibility in public-sector organisations (public sector CSR) in the form of a questionnaire followed up by an interview. Forty-six organisations, i.e. 65% of the members of the Ministry of the environment, energy and the sea's Club for sustainable development of public-sector institutions (CDDEP) undertook the exercise. A CSR barometer was developed in this way, to take stock of the situation, identify the best practices implemented and determine orientations for collective progress.

This enabled Ifremer to assess its level of maturity and commitment on a scale of 1 to 4, and to identify avenues for improvement. The exercise has highlighted our Institute's respectable ranking and shown up ways to progress, and particularly the need to bolster in-house monitoring systems and for all teams to work more closely together.

New integrated management software suite

The Sigma project to implement an integrated management software suite (ERP) at Ifremer was launched by the Institute to optimise its management activities by generally improving the quality of data and by making processing plus reliable, to meet regulatory requirements and to contribute to better running thanks to more comprehensive traceability of information, easier access to retrieval statements and multi-annual project management.

The project to set up an ERP encompasses both an HR aspect (payroll, personnel administration, leave/absences, training courses, yearly interviews) and a Finance aspect (financial management: budget, procurement, revenues, missions, fixed assets, general accounting, analytical accounting, project management). The HR section, which required deploying the HRAccess software package was successfully dealt with as of 2015.

The Finance section was first developed through the Sigma V1 project over the period 2014-2015, which laid the foundations for the new system. The arrival of new and structuring regulatory requirements after the launch

of calls and consultation (especially that of GBCP public-sector budget and accounts management), led to shifting the deployment to 2017 with an updated version called V2 which is better adapted to the new requirements.

The Sigma V2 project started in April 2016, with initial design studies. From mid-September on, it moved into the acceptance testing phase. Along with the test activities, work to prepare the data migration to the new Sigma V2 solution was done for a general technical verification before switching the new system into production. Staff training sessions were held between November 2016 and January 2017.

Concurrently, preparation and organisational changes in the management entities concerned (the Financial affairs and Legal affairs divisions) were engaged, being necessary for the optimal use of the management tool and to take the latest regulatory change into account. New hires were made on the Plouzané site to accompany this.

All these actions led to the effective implementation of the new organisation in January 2017, consistent with the deployment of the new tool.

Budget and financial figures

Financial year 2016

2016 performance shows an increase in Ifremer's working capital to the tune of 10.9 million euros (M€), directly linked to income of 24.56 million euros, resulting from a drop in the spending performed in 2016 (€181.64M to be reconciled with the €187.35M posted in the amending budget) and a rise in (operations) funding entered in the accounts (€206.83M, with respect to the forecast €204.71M).

These figures (income and level of working capital contribution) should be interpreted with caution and should not mask the situation which remains a delicate one. Effectively, this positive balance is due to:

- significant income for headquarters without related spending, but this income is already earmarked for the expenditure to come;
- gaps between the receipt of income and when the expenditure is actually realised;
- rebuilding the Institute's reserves which were compromised by the absence of income which was to come under the European Maritime and Fisheries Fund (EMFF) agreement, which led to using other funds and postponing other programmes. It should be noted that the property and buildings chapter suffered from this lack of available funds;
- from a cyclical gap in payroll, whilst the programme to stabilise the workforce and even do additional hiring did not fully show its effects, particularly in the context of staff leaving, which is beginning to speed up at headquarters.

In coming years, our Institute will be faced with important challenges: transfer of the headquarters, maintaining skill sets and strengthening our teams, the property plan and scientific investments which will call for mobilizing the funds released in 2016.

In fine, the Institute's budgetary performance should be appraised in view of the past year's results. However, that approach alone is not sufficient: it is important to interpret the 2016 performance with respect to 2015 budgetary performance (and to the deduction of 4.9 million euros taken out of the working capital) as well as the forecast budget for the following year (i.e. 2017) so as to correctly measure the commitments and constraints weighing on the Institute.

Resources

In 2016, Ifremer's total assets amounted to €235.87M, which is down -1.95% from the 2016 forecast (240.56 million euros). Not including internal transactions, these resources reached 219.22 million euros, indicating an increase of +1.46 million euros (+0.67%) between the assessment made of potential resources in June 2016 and the assets accounted for on 31st December.

Although internal transactions have no effect on the financial year's results, the variance between the forecast and final figures calls for an explanation. Budgeted at €22.5M, but implemented at €14.56M, the internal transactions item shows significant variance, which is mostly due to the modification of the depreciation/amortization plan adopted in 2016, to scheduling delays in the "capitalization of assets" and to postponing the sale of research vessel *Le Suroît*.

The consolidated resources excluding internal transactions (+1.46 million euros) results from the conjunction of the following elements:

- the subsidy grants for Public Service charges (SCSP), allocated under programme 17.2 reflect the stability of funding granted by the MENESR ministry and posted in 2016 (147.37 million euros) compared to 2015 (147.58 million euros);

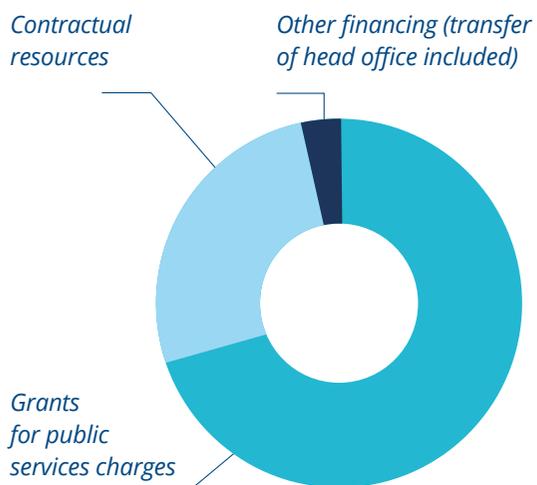
- the amounts of other subsidies for public service charges are also stable. The variance observed is the direct result of a delay in contractualising some assignments ordered by the General division for food /MAAF (-0.82 million euros), which was partially compensated for by an adjustment in the Maritime fisheries and aquaculture division's contribution;

- the contractual funding accounted for corresponds to the budgeted amount (marginal variance of +0.15 million euros, i.e. +0.25%). This stability translates contrasting performance, with income (co-financing for projects / operating revenue) exceeding the objectives set out in the budget (+2.5 million euros) and investment funds, not including operations related to the headquarters' transfer, down by -2.3 million euros;

- an increase of +2.20 million euros for assets accounted for under the financing of the transfer of headquarters, which corresponds to co-financing provided in the framework of the programme to develop seismic equipment. When the budget was drawn up and voted on (during the Board of Directors meeting on 9 June 2016), the state of progress of this dossier and the contract-based approach between the various parties made it possible to post only the financing supplied in the framework of the Datamor State-Region plan and of ARGO, i.e. €1.9M.

Breakdown of resources (not including internal transactions)

2016 budget performance
219.22 million euros



Total resources of Ifremer (in euros)

TOTAL RESOURCES	2016 FORECAST	2016 PERFORMANCE	PERCENTAGE OF TOTAL PERFORMED	TREND 2016 FORECASTS/PERFORMANCE	
				EUROS	%
SCSP subsidy grants for Public Service charges, Headings III and Transfers Headings VI	153,523,178	153,142,266	64.9%	- 380,912	- 0.2%
SCSP / Heading III - Programme 172: Research in the field of environmental and resource management	147,373,178	147,373,178	62.5%	-	100.0%
TRANSFER / Heading VI - Programme 113: Landscapes, water and biodiversity	-	-	-	-	-
TRANSFER / Heading VI - Programme 205: Maritime safety and affairs, fisheries and aquaculture	2,650,000	3,092,088	1.3%	442,088	16.7%
TRANSFER / Heading VI - Programme 206: Food safety and health and hygiene quality	3,500,000	2,677,000	1.1%	- 823,000	- 23.5%
Contractual resources	59,274,252	59,424,084	25.2%	149,832	0.3%
comprising Contractual resources (not including subsidies under programmes 113, 205 and 206)	56,842,254	56,979,767	24.2%	137,513	0.2%
of which subsidies in addition to transfers / Headings VI	2,431,998	2,444,317	1.0%	12,319	0.5%
Funding brought in the framework of transferring the Headquarters	1,900,000	4,109,681	-	2,209,681	116.3%
Write-off of depreciations not related to internal transactions	3,065,000	2,547,819	-	- 517,181	- 16.9%
TOTAL RESOURCES AVAILABLE not including internal transactions	217,762,430	219,223,850	92.9%	1,461,420	0.7%
Net book value of assets written off (internal transactions)	300,000	163,741	0.1%	- 136,259	- 45.4%
Depreciation expenses (internal transactions)	22,500,000	14,563,057	6.2%	- 7,936,943	- 35.3%
TOTAL RESOURCES AVAILABLE (not including capitalised production costs)	240,562,430	233,950,648	99.2%	- 6,611,782	- 2.7%
Capitalised production	-	1,920,761	105.5%	-	-
TOTAL RESOURCES AVAILABLE	240,562,430	235,871,410	100.0%	- 4,691,020	- 2.0%

Contractual operational resources broken down by source of funding (in euros)

CONTRACTUAL RESOURCES	2016 FORECAST	2016 PERFORMANCE	TREND 2016 FORECASTS/ PERFORMANCE
Contribution from French State	6,391,161	6,942,185	551,025
French national research agency	2,854,709	3,387,950	533,241
European Union organisations and international partnerships	12,783,253	14,936,077	2,152,824
Local & regional authorities and other public-sector partnerships	10,968,668	10,779,267	- 189,401
Private-sector partnership	14,151,148	12,838,112	- 1,313,036
Miscellaneous income	4,042,313	4,801,827	759,514
Total	51,191,252	53,685,419	2,494,167

Expenditure

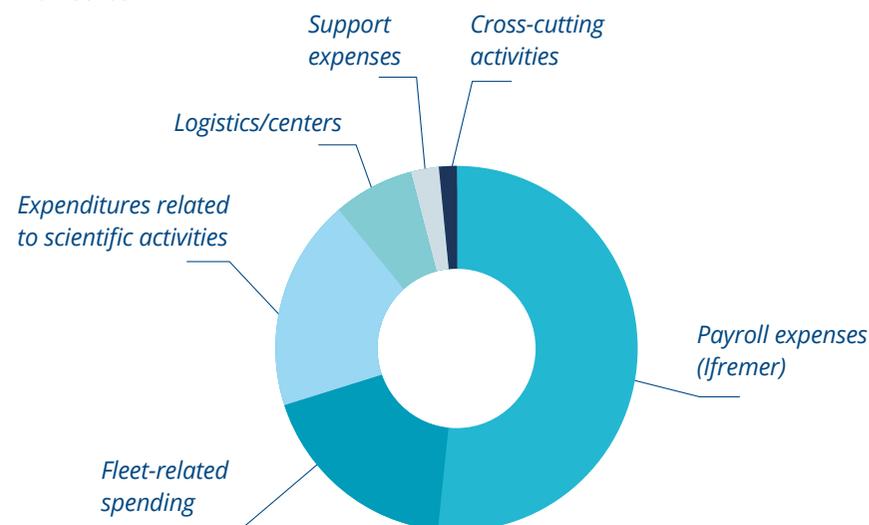
With regard to these means, Ifremer's consolidated expenditure for 2016 amounted to M€ 225.41. Not including internal transactions, these expenses reached €208.76M (for a draft budget of €217.97M adopted in the amending budget). Without internal transactions and depreciations, they were €206.22M (for a draft budget of €214.70M). In the final analysis, they show a difference of -8.48 million euros between the resources initially allocated to teams and the funds actually utilised.

Apart from the earmarked funds set aside for the headquarters relocation, the 2016 performance features a notable decrease in three types of spending:

- a drop in staff costs (-3.37 million euros),
- a drop in expenses related to fleet scheduling (-2 million euros),
- an overall cyclical downturn in spending under the heading of scientific activities, essentially due to the postponement of the Datarmor and "new-generation seismics" operations.

Breakdown of expenditure (not including depreciation and internal transactions)

2016 budget performance
206.22 million euros



Total expenditure of Ifremer (in euros)

TOTAL EXPENDITURE	2016 FORECAST	2016 PERFORMANCE	Percentage of total expenditure performed	TREND 2016 FORECASTS/ PERFORMANCE	
				EUROS	%
Payroll expenses (Ifremer)	110,681,057	107,308,871	52.0%	- 3,372,186	- 3.0%
Fleet-related spending	39,808,525	37,843,498	18.4%	- 1,965,027	- 4.9%
Expenses related to scientific activities	39,737,640	37,674,894	18.3%	- 2,062,746	- 5.2%
Logistics / Centres	14,913,030	15,372,697	7.5%	459,667	3.1%
Support expenses	3,472,178	4,338,852	2.1%	866,674	25.0%
Cross-cutting activities	3,685,000	3,678,301	1.8%	- 6,699	- 0.2%
Transfer of headquarters (funds reserved)	2,400,000	0	ns	- 2,400,000	ns
Total expenditure (not including depreciation and internal transactions)	214 697 430	206 217 113	100%	- 8 480 317	- 3.9%
Depreciation, share of revalued assets	865,000	863,069		1,931	- 0.2%
Other depreciations not including internal transactions	2,200,000	1,684,750		- 515,250	- 23.4%
Depreciations not including internal transactions	3,065,000	2,547,819		- 517,181	- 16.9%
Net book value of assets written off (internal transactions)	300,000	163,741		- 136,259	- 45.4%
Depreciation expenses (internal transactions)	22,500,000	14,563,057		- 7,936,943	- 35.3%
Internal transactions	22,800,000	14,726,798		- 8,073,202	- 35.4%
Total expenditure (including depreciation and internal transactions)	240,562,430	223,491,730		- 17,070,700	- 7.1%
Payroll expenses (Ifremer + Genavir)	131,764,057	128,348,672		- 3,415,385	- 2.6%

BALANCE AT CLOSING BEFORE ALLOCATION OF PROFIT OR LOSS (EUROS)

BALANCE SHEET - ASSETS	2016			2015	Trend
	Gross	Depreciation and provisions	Net	Net	
FIXED ASSETS					
INTANGIBLE FIXED ASSETS					
Set-up costs	13,270.16	13,270.16	0.00	0.00	-
Research and development costs	0.00	0.00	0.00	13,111.11	-100.0%
Concessions and similar rights, patents, licences, trademarks, processes, software, entitlements and securities	38,527,293.68	31,184,545.09	7,342,748.59	3,512,695.73	109.0%
Purchased goodwill	0.00	0.00	0.00	0.00	-
Other intangible fixed assets	208,522.16	208,522.16	0.00	0.00	-
Intangible assets in progress	4,384,602.03	0.00	4,384,602.03	5,006,275.04	-12.4%
Advances and prepayments on fixed asset orders	4,287,546.85	0.00	4,287,546.85	2,930,740.01	46.3%
TOTAL - INTANGIBLE FIXED ASSETS	47,421,234.88	31,406,337.41	16,014,897.47	11,462,821.89	39.7%
TANGIBLE FIXED ASSETS					
Land and developments	7,553,442.13	1,155,136.37	6,398,305.76	6,344,404.91	0.8%
Buildings	119,493,753.62	71,615,994.41	47,877,759.21	49,274,197.33	-2.8%
Industrial fixtures, fittings, plant machinery and equipment	126,183,575.35	114,538,737.41	11,644,837.94	11,797,619.68	-1.3%
Collections	872,856.49	0.00	872,856.49	895,724.14	-2.6%
Vessels and underwater vehicles	219,494,081.49	139,329,600.57	80,164,480.92	82,780,696.39	-3.2%
Other tangible fixed assets	34,869,102.93	32,098,123.20	2,770,979.73	2,965,690.35	-6.6%
Tangible assets in progress	7,484,954.31	0.00	7,484,954.31	6,187,069.85	21.0%
Advances and prepayments on fixed asset orders	24,679,795.76	0.00	24,679,795.76	17,823,758.43	38.5%
TOTAL - TANGIBLE FIXED ASSETS	540,631,562.08	358,737,591.96	181,893,970.12	178,069,161.08	2.1%
INVESTMENTS					
Holdings	671,857.68	160,379.60	511,478.08	515,578.08	-0.8%
<i>incl. other forms of investment (Quae)</i>	125,000.00	0.00	125,000.00	125,000.00	0.0%
Receivables attached to holdings	0.00	0.00	0.00	0.00	-
Portfolio investments	0.00	0.00	0.00	0.00	-
Other investments	0.00	0.00	0.00	0.00	-
Loans	5,855,245.80	0.00	5,855,245.80	5,716,334.10	2.4%
Other (deposits and guarantees paid)	640,399.76	0.00	640,399.76	441,130.17	45.2%
TOTAL - INVESTMENTS	7,167,503.24	160,379.60	7,007,123.64	6,673,042.35	5.0%
TOTAL - FIXED ASSETS	595,220,300.20	390,304,308.97	204,915,991.23	196,205,025.32	4.4%

FINANCIAL RESULTS

BALANCE SHEET - ASSETS	2016			2015	Trend
	Gross	Depreciation and provisions	Net	Net	
CURRENT ASSETS					
TOTAL - INVENTORIES AND WORK IN PROGRESS	0.00	0.00	0.00	0.00	-
TOTAL - ADVANCES AND PREPAYMENTS ON ORDERS	3,721,186.44	0.00	3,721,186.44	3,918,547.17	-5.0%
DEBTS					
Customer and related accounts receivable	11,225,922.87	1,585,987.63	9,639,935.24	7,156,928.29	34.7%
Other	32,639,850.94	0.00	32,639,850.94	26,826,380.41	21.7%
<i>incl. Payroll and related accounts</i>	113,838.38	0.00	113,838.38	120,345.15	-5.4%
<i>incl. Social Security and social organisations</i>	22,553.35	0.00	22,553.35	0.00	
<i>incl. State and local authorities</i>	32,503,459.21	0.00	32,503,459.21	26,706,035.26	
<i>incl. Subsidies</i>	7,153,283.72	0.00	7,153,283.72	6,686,152.39	
TOTAL - DEBTS	43,865,773.81	1,585,987.63	42,279,786.18	33,983,308.70	24.4%
TOTAL - NON-OPERATING LIABILITIES	188,614.90	0.00	188,614.90	1,064,312.41	-82.3%
AVAILABLE FUNDS					
Shares (listed securities)	0.00	0.00	0.00	0.00	-
Other securities	0.00	0.00	0.00	0.00	-
Banking	46,018,344.00	0.00	46,018,344.00	36,003,922.48	27.8%
<i>incl. Private banks</i>	1,275,457.66	0.00	1,275,457.66	459,248.05	177.7%
<i>incl. Public finances general directorate</i>	44,732,032.90	0.00	44,732,032.90	35,536,190.30	25.9%
Cash account	0.00	0.00	0.00	3,165.62	-100.0%
Service authorising expenses to be incurred	48,978.48	0.00	48,978.48	49,449.87	-1.0%
Service enabling funds to be received	0.00	0.00	0.00	50.00	-100.0%
TOTAL - AVAILABLE FUNDS	46,067,322.48	0.00	46,067,322.48	36,056,587.97	27.8%
ADJUSTMENTS					
Prepaid expenses	14,941.14	0.00	14,941.14	26,307.76	-43.2%
TOTAL - ADJUSTMENTS	14,941.14	0.00	14,941.14	26,307.76	-43.2%
TOTAL - CURRENT ASSETS	93,857,838.77	1,585,987.63	92,271,851.14	75,049,064.01	22.9%
TOTAL - ASSETS	689,078,138.97	391,890,296.60	297,187,842.37	271,254,089.33	9.6%

BALANCE AT CLOSING BEFORE ALLOCATION OF PROFIT OR LOSS (EUROS)

BALANCE SHEET - LIABILITIES	Financial year 2016	Financial year 2015	Trend
EQUITY			
CAPITAL			
ALLOCATION CONTRIBUTIONS			
State - Allocations	347,193.57	347,193.57	0.0%
State - Additional allocations	497,008,523.35	497,528,413.76	-0.1%
Other organisations - Additional allocations	0.00	0.00	-
Reversed to income statement	-364,564,248.94	-355,070,918.96	2.7%
Capital donations and legacies	0.00	0.00	-
Premiums from share issues, mergers, assets brought in	0.00	0.00	-
TOTAL - ALLOCATION CONTRIBUTIONS	132,791,467.98	142,804,688.37	-7.0%
TOTAL - REEVALUATION RESERVES OR SURPLUS	18,760,830.03	18,760,830.03	0.0%
RESERVES			
Legal reserve	0.00	0.00	-
Statutory or contractual reserves	0.00	0.00	-
Regulated reserves	0.00	0.00	-
Optional reserves	18,487,753.60	5,190,947.72	256.2%
Other reserves	0.00	0.00	-
TOTAL - RESERVES	18,487,753.60	5,190,947.72	256.2%
BALANCE BROUGHT FORWARD	1,172,693.73	228,164.75	414.0%
RESULT FOR FINANCIAL YEAR (PROFIT OR LOSS)	24,561,745.10	14,223,938.53	72.7%
INVESTMENT GRANTS			
Investment grants	31,240,056.04	25,362,775.53	23.2%
Reversed to income statement	-15,681,316.92	-14,399,665.43	8.9%
TOTAL - INVESTMENT GRANTS	15,558,739.12	10,963,110.10	41.9%
TOTAL - EQUITY CAPITAL	211,333,229.56	192,171,679.50	10.0%
PROVISIONS			
Provisions for contingencies	1,631,000.00	1,611,000.00	1.2%
Provisions for expenses	17,423,298.12	16,884,833.82	
<i>incl. Provisions for pensions and similar obligations</i>	12,691,128.08	12,660,320.08	0.2%
<i>incl. Provisions for UNEDIC commitments</i>	3,754,373.18	3,345,498.18	12.2%
<i>incl. other Provisions for charges</i>	977,796.86	879,015.56	11.2%
TOTAL - PROVISIONS	19,054,298.12	18,495,833.82	3.0%

	Financial year 2016	Financial year 2015	Trend
LIABILITIES			
LOANS AND RELATED LIABILITIES			
Convertible debenture loans	0.00	0.00	-
Other debenture loans	0.00	0.00	-
Loans and liabilities from credit institutions	0.00	0.00	-
Misc. loans and financial debts	34,771.41	34,771.41	0.0%
TOTAL - LOANS AND RELATED LIABILITIES	34,771.41	34,771.41	0.0%
ADVANCES AND PREPAYMENTS ON ORDERS	168,785.67	537,058.34	-68.6%
OPERATING LIABILITIES			
Trade accounts payable and related accounts	11,345,404.36	8,407,947.08	34.9%
Tax and social security payable	47,841,590.23	42,963,933.89	11.4%
<i>incl. Payroll and related accounts</i>	12,014,028.62	11,465,690.95	4.8%
<i>incl. Social Security and social organisations</i>	10,079,168.24	11,150,164.59	
<i>incl. State and local authorities</i>	9,546,995.47	5,352,553.46	
<i>incl. Advances and prepayments received on grants</i>	16,201,397.90	14,995,524.89	8.0%
TOTAL - OPERATING LIABILITIES	59,186,994.59	51,371,880.97	15.2%
NON-OPERATING LIABILITIES			
Liabilities on assets and related accounts	4,359,389.11	5,131,612.91	-15.0%
Other liabilities	2,981,614.36	3,462,058.38	-13.9%
TOTAL - NON-OPERATING LIABILITIES	7,341,003.47	8,593,671.29	-14.6%
ADJUSTMENTS	0.00	0.00	-
Deferred income	68,759.55	49,194.00	39.8%
TOTAL - ADJUSTMENTS	68,759.55	49,194.00	39.8%
TOTAL - LIABILITIES	66,800,314.69	60,586,576.01	10.3%
Conversion losses	0.00	0.00	-
TOTAL - LIABILITIES	297,187,842.37	271,254,089.33	9.6%

RESULTS (€) - PART 1	Financial year 2016	Financial year 2015	Trend
OPERATING INCOME			
Sales of goods	8.33	58.32	-85.7%
Revenues from studies and service provision	19,512,446.32	16,103,974.91	21.2%
Revenues from related activities	2,045,906.91	2,016,035.37	1.5%
Production sold	21,558,353.23	18,120,010.28	19.0%
Net turnover	21,558,361.56	18,120,068.60	19.0%
Stock of finished goods	0.00	0.00	-
Capitalised production	1,920,761.34	1,583,524.88	21.3%
TOTAL - PRODUCTION FOR FISCAL YEAR	23,479,122.90	19,703,593.48	19.2%
Subsidies for public service responsibilities	155,586,583.00	156,015,728.60	-0.3%
Subsidies from National research agency	3,365,844.69	1,843,410.57	82.6%
Other non-taxable subsidies received from State	7,155,883.23	568,824.66	1158.0%
Other non-taxable subsidies received from local authorities	849,434.52	1,449,050.52	-41.4%
Non-taxable subsidies received from other public bodies	12,602,082.63	12,498,164.32	0.8%
Other operating grants	1,668,126.48	1,666,142.69	0.1%
TOTAL - OPERATING SUBSIDIES	181,227,954.55	174,041,321.36	4.1%
Share written off of funding related to assets	14,726,798.18	20,558,868.11	-28.4%
Reversals of provisions	996,449.32	1,374,370.03	-27.5%
Transfers of operating expenses	1,055,939.30	66,278.87	1493.2%
Write-off of provisions and depreciations / transfers of expenses	16,779,186.80	21,999,517.01	-23.7%
Other revenues	1,659,261.13	1,832,707.33	-9.5%
TOTAL - OPERATING INCOME	223,145,525.38	217,577,139.18	2.6%

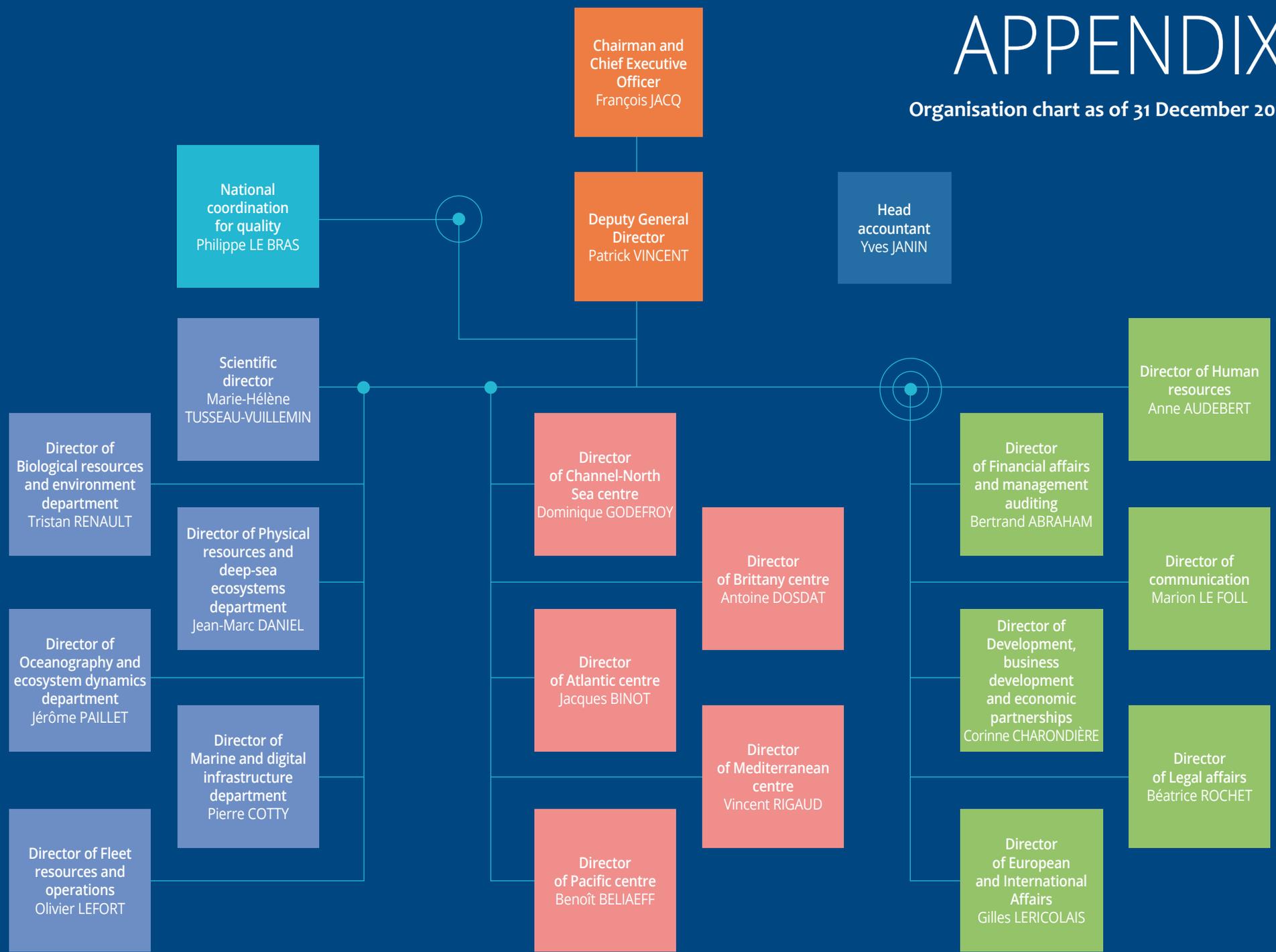
	Financial year 2016	Financial year 2015	Trend
OPERATING COSTS			
Raw materials	0.00	0.00	-
Other supplies	0.00	0.00	-
Purchases of goods	0.00	0.00	-
Raw materials	0.00	0.00	-
Other supplies	0.00	0.00	-
Change in stock	0.00	0.00	-
Other purchases and external charges	6,256,692.89	5,780,476.42	8.2%
Purchases of studies and services	0.00	43,022.01	-100.0%
Purchases of equipment, plant and work	1,466.53	6,017.30	-75.6%
Purchases incorporated in products	1,466.53	49,039.31	-97.0%
TOTAL - PURCHASES	6,258,159.42	5,829,515.73	7.4%
Outsourcing and subcontracting	33,203,535.30	36,647,242.63	-9.4%
Rentals and rental expenses	1,303,227.93	1,534,761.05	-15.1%
Maintenance	5,819,774.43	4,773,045.48	21.9%
Insurance premiums	775,170.45	879,375.08	-11.8%
Studies and research	555,219.78	934,237.70	-40.6%
Miscellaneous	627,739.81	682,587.00	-8.0%
Outside staff	305,469.40	548,046.23	-44.3%
Payments to intermediaries and fees	605,983.30	488,332.55	24.1%
Advertising, publications, external relations	233,187.62	285,873.16	-18.4%
Freight and collective staff transport	375,922.96	423,186.09	-11.2%
Travel, missions and receptions	4,478,045.91	4,470,141.25	0.2%
Postal and telecommunications costs	961,492.65	985,141.86	-2.4%
Banking and related services	3,136.43	1,267.12	147.5%
Miscellaneous	15,494,225.44	14,157,277.23	9.4%
TOTAL - OUTSIDE SERVICES	64,742,131.41	66,810,514.43	-3.1%
Total intermediate expenses	71,000,290.83	72,640,030.16	-2.3%
Payroll taxes	8,153,798.97	7,900,015.31	3.2%
Taxes and other organisations	1,373,713.42	1,320,984.22	4.0%
TOTAL - TAXES, DUTIES AND SIMILAR LEVIES	9,527,512.39	9,220,999.53	3.3%
Salaries and appointments	68,403,134.00	66,755,253.95	2.5%
Social contributions	29,038,864.31	30,272,170.76	-4.1%
TOTAL - PAYROLL EXPENDITURE	97,441,998.31	97,027,424.71	0.4%

RESULTS (€) - PART 2	Financial year 2016	Financial year 2015	Trend
Depreciation of fixed assets	17,105,392.30	21,996,036.60	-22.2%
Impairment of fixed assets	0.00	0.00	-
Impairment of current assets	584,298.13	203,361.50	187.3%
Provisions for contingencies and charges	888,033.00	1,090,380.00	-18.6%
Depreciation, amortization and impairment of fixed assets	18,577,723.43	23,289,778.10	-20.2%
Other charges	1,678,961.13	1,234,186.36	36.0%
TOTAL - OPERATING COSTS	198,226,486.09	203,412,418.86	-2.5%
OPERATING INCOME	24,919,039.29	14,164,720.32	75.9%
Share of profits or losses from joint operations or ventures	0.00	0.00	-
Profit or transferred loss	0.00	0.00	-
Loss or transferred profit	0.00	0.00	-
FINANCIAL INCOME			
Income from equity holdings	263,250.00	70,911.00	271.2%
Income from securities and financial fixed asset receivables	0.00	5,390.97	-100.0%
Other interest and related income	281.10	281.60	-0.2%
Reversals of provisions	8,232.25	0.00	-
Transfers of charges	0.00	0.00	-
Reversals of provisions and transfers of charges	8,232.25	0.00	-
Realised gains on exchange differences	4,500.46	9,473.87	-52.5%
Proceeds from sale of securities	0.00	0.00	-
TOTAL - FINANCIAL INCOME	276,263.81	86,057.44	221.0%
FINANCIAL EXPENSES			
Depreciation and provisions	4,100.00	0.00	-
Interest and related expenses	0.60	159.14	-99.6%
Realised exchange losses	3,544.62	9,385.72	-62.2%
Net loss from sale of securities	0.00	0.00	-
TOTAL - FINANCIAL EXPENSES	7,645.22	9,544.86	-19.9%
FINANCIAL PROFIT OR LOSS	268,618.59	76,512.58	251.1%
INCOME BEFORE TAX	25,187,657.88	14,241,232.90	76.9%

	Financial year 2016	Financial year 2015	Trend
EXTRAORDINARY INCOME			
Extraordinary income from management operations	15,890.48	11,857.00	34.0%
Proceeds from disposal of assets	36,779.34	799,610.60	-95.4%
On capital operations	36,779.34	799,610.60	-95.4%
Other extraordinary income	785.28	838.00	-6.3%
Reversals of provisions and transfers of charges	0.00	0.00	-
TOTAL - EXTRAORDINARY INCOME	53,455.10	812,305.60	-93.4%
EXTRAORDINARY EXPENSES			
Extraordinary income from management operations	460,986.22	438,619.13	5.1%
Net book value of assets sold	169,224.69	274,581.22	-38.4%
Other extraordinary charges	24,156.97	91,399.62	-73.6%
On capital operations	193,381.66	365,980.84	-47.2%
Depreciation and provisions	0.00	0.00	-
TOTAL - EXTRAORDINARY CHARGES	654,367.88	804,599.97	-18.7%
EXTRAORDINARY RESULT	-600,912.78	7,705.63	-7898.4%
Employees profit sharing	0.00	0.00	-
Corporate tax	25,000.00	25,000.00	0.0%
GROSS PROFIT OR LOSS	24,586,745.10	14,248,938.53	72.6%
TOTAL - INCOME	223,475,244.29	218,475,502.22	2.3%
TOTAL - EXPENSES	198,913,499.19	204,251,563.69	-2.6%
PROFIT (+) OR LOSS (-)	24,561,745.10	14,223,938.53	72.7%

APPENDIX

Organisation chart as of 31 December 2016



BOARD OF DIRECTORS as of 4 October 2016

CHAIRMAN
François JACQ

MEMBERS REPRESENTING THE STATE

Ministry in charge of Higher education and research
Elisabeth VERGÈS
Alternate: Bernard COMMERE

Ministry of the Environment, energy and the sea
Philippe COURTIER
Alternate: Aurélie SUNARA

Laure TOURJANSKY
Alternate: Maximilien SIMON

Ludovic SCHULTZ
Alternate: Stéphanie CUBIER

Ministry of Defence
Rear Admiral Bernard-Antoine MORIO DE L'ISLE
Alternate: Captain (Navy) Lionel PILLAN

Ministry in charge of Economy and finance
Nicolas HENGY

Ministry in charge of Industry and digital affairs
Sylvie METZ-LARUE
Alternate: François VILLEREZ

Ministry of Foreign affairs and international development
Clélia CHEVRIER KOLACKO
Alternate: Anisse BEN YOUNES

MEMBERS CHOSEN FOR THEIR EXPERTISE IN FIELDS CLOSE TO THOSE OF IFREMER

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General secretary French national association of maritime fisheries and mariculture producer organisations

Michel EDDI
Chairman of CIRAD

Françoise MÉCHIN
IFP Énergies nouvelles

Stéphanie THIÉBAULT
Director (InEE) ecology and environment institute of CNRS

Gérald VIAUD
Chairman of CNC national shellfish-farming committee

MEMBERS ELECTED BY IFREMER PERSONNEL

CFDT
Loïc LE DÉAN
Loïc PETIT DE LA VILLÉON
Catherine SATRA LE BRIS
Jean TOURNADRE
Cathy TREGUIER

CGT
Joël KNOERY
Carla SCALABRIN

MEMBERS VOTING IN ADVISORY CAPACITY

Government commissioner
Thierry BERGEONNEAU

Secretary general for the Sea
Vincent BOUVIER

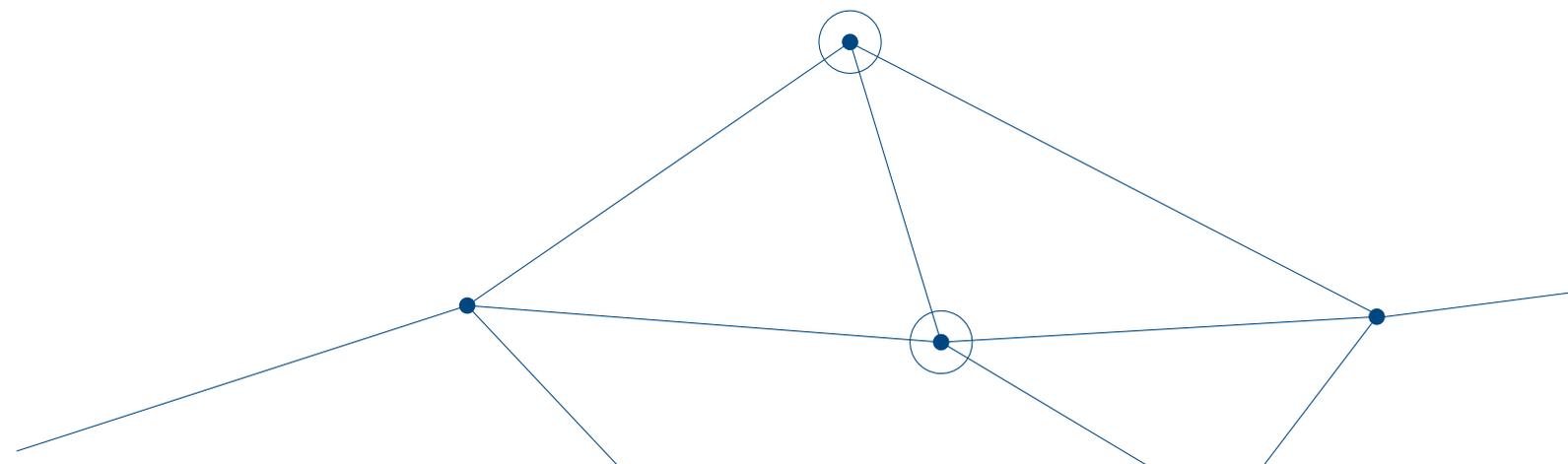
Representative of Ministry in charge of French overseas departments
Marie-Pierre CAMPO

General comptroller for finance and economics
Philippe DEBET

Chairman of Ifremer's scientific committee
Patrick LANDAIS

Head Accountant of Ifremer
Yves JANIN

CCE secretary
Jean-Bernard DONOU



SCIENTIFIC COMMITTEE as of 4 October 2016

MEMBERS APPOINTED BY JOINT DECISION OF THE SUPERVISORY AUTHORITY MINISTRIES

Patrick LANDAIS
Chairman
Deputy director for innovation
and development at ANDRA

Denis ALLEMAND
Scientific director of the Scientific centre
of Monaco

Chris BOWLER
Director of research CNRS, École normale
supérieure,
Director of Ecological and Evolutionary
Genomics section

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Professor at University of La Sapienza,
Earth sciences, Rome (Italy)

Pascale DELECLUSE
Director of INSU at CNRS

Marion GEHLEN
Director of research CEA, laboratory
of environmental and climate sciences,
Gif-sur-Yvette

Peter M. J. HERMAN
Senior Adviser, Deltares, Marine and Coastal
Systems, Delft (The Netherlands)

François LALLIER
Director of UMR joint research unit
on Adaptation and diversity in the marine
environment, Pierre & Marie Curie
University, Roscoff

Marina LÉVY
Director of research CNRS, Laboratory
of oceanography and climate experiments
and digital approaches Pierre Simon
Laplace institute, Paris

Jean-Marie MOUCHEL
Professor, Pierre & Marie Curie University,
Paris, director of Piren Seine programme

Fabienne PETIT
Professor, University of Rouen, director
of Federation Sciences applied to the
environment

Edwige QUILLET
Director of research at INRA, head of
Aquaculture genetics team, UMR GABI,
Jouy-en-Josas

Hélène REY-VALETTE
Lecturer, UMR Lameta, Faculty
of economics, Montpellier

MEMBERS ELECTED BY IFREMER PERSONNEL

Marie-Édith BOUHIER, CFDT full member
Acoustics engineer

Franck COPPIN, CFDT substitute
Fisheries dynamics engineer

Catherine DREANNO, CGT substitute
Research scientist in molecular biology

Raymond KAAS, CGT full member
Research scientist in algal ecophysiology
and biology

Karine OLU-LE ROY, CFDT substitute
Research scientist in ecology
of chemosynthesis systems, life science

Jean-François PÉPIN, CFDT full member
Mollusc animal health supervisor

PERMANENT GUEST MEMBERS

François CARLOTTI
Mer AllEnvi task group, deputy director
of the Mediterranean institute of scientific
oceanology

Jacqueline GARNIER-LAPLACE
Risques AllEnvi task group, director
of Research and expert assessment
of environmental hazards department,
Institute of radioprotection and
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Sylvie REBUFFAT
Professor, National museum of natural
history
AllEnvi scientific steering committee

Thomas CHANGEUX
Mer AllEnvi task group, AllEnvi Overseas
France committee, IRD

SCIENTIFIC COMMITTEE SECRETARY

Marie-Hélène TUSSEAU-VUILLEMIN
Scientific director of Ifremer

TECHNICAL AND INDUSTRIAL COMMITTEE as of 4 October 2016

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Chairwoman

Eric PAPIN
DCNS

Pierre BALIGUET
Sercel

Arnaud BOCQUET
Pierre Fabre

Maurice BOUTECA
IFP Energies Nouvelles

Julien DENEGRE
Technip

Marie-Christine HUAU
Véolia

Gérard JACQUIN
INRA

Bruno JARRY
Académie des Technologies

Jean-Claude LE BLEIS
NKE

Fabien NAPOLITANO
Ixblue

Éric CAUQUIL
Total

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Eramet

Jean-Pierre VADET
ECA Robotics

Jean-Baptiste De FRANCQUEVILLE
**Ministry of the Environment, energy and
the sea**

Thomas LOMBES
**Ministry of Higher education
and research**

IFREMER PARTICIPANTS

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CFDT trade union representative

Ingrid PUILLAT
CGT trade union representative

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